

**THE NATURAL GAS
RESEARCH, DEVELOPMENT,
AND DEMONSTRATION PROGRAM**

Proposed Program Plan and
Funding Request for
Fiscal Year 2009-2010

STAFF REPORT

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Executive Summary

In 2004, the California Public Utilities Commission (CPUC) asked the California Energy Commission (Energy Commission) to administer a ratepayer-funded natural gas research program.¹ This 2009-2010 *Energy Commission Natural Gas Research Development and Demonstration (RD&D) Budget Proposal* is the fifth budget plan submitted to the CPUC since 2005 and covers the period beginning July 1, 2009 and ending June 30, 2010. The *Energy Commission Natural Gas RD&D Budget Proposal* details several needs that are relevant to California's natural gas ratepayers and stakeholders, and affect the Energy Commission's long-term natural gas RD&D planning.

The *Energy Commission Natural Gas RD&D Budget Proposal* divides primary research activities into four topics based areas identified by the 2008 *Energy Action Plan*:

- Improving residential, commercial, and industrial energy efficiency.
- Accelerating the adoption of clean alternatives to conventional natural gas resources and technologies.
- Improving natural gas system and infrastructure performance and reliability.
- Reducing the environmental footprint of California's natural gas system.

The Energy Commission believes that the state energy "loading order" for new electricity resources is ideally suited for application to natural gas resources. The loading order prioritizes for natural gas energy efficiency and demand response, renewable and clean distributed resources, and systems-level infrastructure improvements. The first three proposed research topic areas allow California to address its growing demand for natural gas in a manner consistent with this loading order. The final research topic area has strategic significance for energy-smart growth and is guided by key policy mandates and directives such as the *State Alternative Fuels Plan*² and Assembly Bill 32³.

The Proposed Fiscal Year (FY) 2009-2010 Energy Commission budget is \$24 million for its natural gas research effort including, \$19.6 million to be spent directly on specific research projects and grants with an additional \$1.75 million for solicitations through the Energy Innovation Small Grants program (Table 1). The proposed Program Administration for FY 2009-2010 has been reduced to 11 percent from the 15 percent in the FY 2008-2009 budget plan.

¹ CPUC Decision 04-08-010 (http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/39314.htm)

² <http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CMF.PDF>

³ Núñez, Chapter 488, Statutes of 2006, the California Global Warming Solutions Act of 2006 (http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.html)

Table 1: FY 09-10 Natural Gas Budget Plan Summary

Research Topic Areas	Budget (\$ MM)
Improving Residential, Commercial and Industrial Energy Efficiency	\$9.95
Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies	\$4.95
Improve Natural Gas System and Infrastructure Performance and Reliability	\$1.70
Reducing the Environmental Footprint of California's Natural Gas System	\$3.00
Energy Innovation Small Grants Program	\$1.75
Program Administration	\$2.65
TOTAL	\$24.00

Summary of Research Topic Areas

Improving Residential, Commercial and Industrial Energy Efficiency

Reflecting the state energy loading order, the Energy Commission considers natural gas process and end-use efficiency its highest priority research topic area. Research efforts will identify and develop opportunities to achieve greater energy efficiency benefits with existing or market-ready technologies to provide near-term and long-term benefits for California residents and the state economy.

The proposed budget plan would support research on energy efficiency through six core areas: improved efficiency of the hot water distribution system; improved efficiency of food service operations; improved efficiency of industrial and institutional natural gas use; demonstration of emerging technologies for industrial applications; development of advanced distribution systems for residential space heating; and, development and demonstration of advanced fuel-efficient transportation technologies and fuel switching strategies that result in cost-effective reduction of on-road and off-road petroleum fuel use in the short and long-term.

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

Consistent with the loading order, the proposed budget plan assigns secondary priority to reduced dependence on imported natural gas by diversifying supplies. Research in this area focuses primarily on California's abundant renewable resources, including solar, wind, geothermal and bio-energy. This research will allow California to replace natural gas fired power plants with clean renewable resources. An ongoing initiative on the development of renewable, energy-secure communities at the Energy Commission is building on results from completed research on renewable technologies. The eventual deployment of market-ready renewable natural gas alternatives, which could substantially reduce natural gas demand, is also among the Energy Commission's most prominent research goals.

Key research projects include development of a low-cost and thermally efficient energy storage system for concentrating solar power; development of energy efficient, cost effective, safe, clean, durable and reliable combined heat and power, and distributed energy resources technologies; development of gas-fired commercial heating/power systems and cooling solutions augmented by renewable resources; and, research, development and deployment of alternative fuels that

reduce petroleum consumption and transportation-related greenhouse gas emissions while assisting economic development within the state of California.

Improve Natural Gas System and Infrastructure Performance and Reliability

The third priority in the loading order is infrastructure improvement combined with the first two priorities, energy efficiency and clean generation. The proposed budget plan reflects the importance of ensuring the safety and security of the state's natural gas infrastructure. An aging infrastructure and growing demand for natural gas pose significant long-term challenges for the state's natural gas system, its ratepayers and other stakeholders.

Key research areas include the identification and assessment of integrating opportunities between California's natural gas system and smart grid technologies and facilitating energy efficient consumer behavior.

Reducing the Environmental Footprint of California's Natural Gas System

To achieve the long-term greenhouse gas emissions reductions targets mandated by Assembly Bill (AB) 32, California must establish an environmentally sound natural gas system. Key targets include efficiency and optimizing the use of natural gas, especially for heating and industrial purposes.

The proposed budget plan supports research projects that would expand, develop and diversify California's natural gas system while complying with state and federal environmental, health and safety regulations.

The three core initiatives in this research area include assessing the impacts of global climate change; developing strategies to reduce direct and indirect greenhouse gas emissions associated with natural gas; and, improving the understanding of and developing solutions to reduce the impacts of natural gas production, distribution, storage and use on air quality, biological diversity, land use, public health, and water quality.

Energy Innovations Small Grants Program

The Energy Commission's Energy Innovations Small Grants Program provides research grants to businesses, non-profits, individuals, national laboratories, utilities, academic institutions and other qualifying entities for research that establishes the feasibility of new, innovative energy concepts. The program currently supports projects that complement larger-budget natural gas research projects.

Beginning in FY 2009-2010, the Energy Commission would create a separate solicitation process for small grants research focused specifically on transportation. These grants would support the Energy Commission's alternative fuels research and complement the natural gas research areas by funding projects that reduce the consumption of petroleum-based fuels by promoting and advancing renewable and non-renewable alternative fuels using innovative tools and methods.

Program Administration

This budget plan proposes allocating 11 percent of the total budget to administrative expenses, which includes personnel expenses and non-research technical support. This would represent a

decrease from FY 2008-2009, in which administrative expenses were 15 percent of the total budget.

CHAPTER 1:

Introduction

In 2004, the California Public Utilities Commission (CPUC) directed collection of a ratepayer-funded natural gas surcharge for energy research and assigned the California Energy Commission (Energy Commission) to administer that research⁴. The Energy Commission's Public Interest Energy Research (PIER) Natural Gas program has since been updated by legislation: Senate Bill (SB) 1250¹⁴, that changed how the natural gas research funds are encumbered and managed; and SB 76⁵, which added transportation research as an integral element of natural gas research at the Energy Commission. The Energy Commission's natural gas research is driven by energy policies identified in the *Energy Action Plans, Integrated Energy Policy Reports (IEPR)* and the *State Alternative Fuels Plan*⁶. In addition, the Energy Commission has sought input from experts in energy and environmental research, research organizations, the state's investor-owned gas utilities and other interested parties throughout the development of these natural gas research priorities.

As program administrator for the natural gas research program since 2005, the Energy Commission has completed numerous successful Research Development and Demonstration (RD&D) projects, and continues funding additional projects that promise significant benefits for natural gas ratepayers in California. The Energy Commission leverages efforts in its natural gas and electricity research programs to advance and refine its overall ratepayer-funded research portfolio. The benefits from the natural gas research projects will continue to accumulate over time through follow-on activities undertaken by other researchers and industry, and through informed policymaking that recognizes the long-term nature of energy research and development.

Natural Gas Research Vision

The Energy Commission pursues strategic investments in RD&D that recognize the central role natural gas plays in meeting the state's energy needs and helping achieve its emissions reduction targets.

The proposed budget plan identifies four research topic areas that support this vision:

- Improve residential, commercial, and industrial energy efficiency.
- Accelerate the adoption of clean alternatives to conventional natural gas resources and technologies.
- Improve natural gas system and infrastructure performance and reliability.
- Reduce the environmental footprint of California's natural gas system.

⁴ CPUC Decision 04-08-010 (http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/39314.htm)

⁵ Committee on Budget and Fiscal Review, Chapter 91, Statutes of 2005
(http://www.leginfo.ca.gov/pub/05-06/bill/sen/sb_0051-0100/sb_76_bill_20050721_chaptered.pdf)

⁶ <http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CMF.PDF>

The proposed research topic areas are consistent with the state energy loading order: first, energy efficiency; second, clean energy; and third, clean and efficient generation.

These proposed research topic areas also reflect three high-level research objectives established by the Energy Commission: stimulate economic growth in California, identify and achieve long-term natural gas goals, and capture the benefits of integrating electricity and natural gas research. The first two objectives are embedded in the policy and legislative direction that established these research efforts. The third objective emerged from the Energy Commission's concurrent management of the natural gas and electricity research.

Furthermore, the Energy Commission remains flexible to rapidly changing new and emerging energy technologies. Selection of past projects reflect the core research vision and have resulted in numerous successful results including valuable research that may not have been initially.

Capture Benefits of Integrated Electricity and Natural Gas Research

The Energy Commission has strived to identify and capture research opportunities shared by its natural gas and electricity programs. Improving the efficiency of the electricity system will result in significant savings because natural gas accounts for over 45 percent of California's electricity generation mix⁷. Moreover, greenhouse gas (GHG) reduction targets outlined in SB1368⁸ and AB 32 could suggest increasing natural gas use to replace higher-carbon fuel sources.

A smaller scale illustration of these strategic overlaps is exemplified by combined heat and power (CHP) systems, which achieve superior electrical and thermal efficiency through on-site electricity generation. Another notable example is natural gas-powered distributed generation, which is viewed as a promising solution to mitigate intermittency of renewable resources such as solar photovoltaic. The overlaps in natural gas and electricity research also promise benefits for California's electric system. Plug-in hybrid electric vehicles co-fueled by natural gas and electricity, as recommended in the State Alternative Fuels Plan, perfectly illustrate the dual benefits accruing to each research program through coordination of development and deployment. Through its diligent efforts to integrate electricity and natural gas wherever applicable, the Energy Commission has created a well rounded public interest energy research portfolio that takes advantage of cross-cutting benefits of improved natural gas and electricity efficiency.

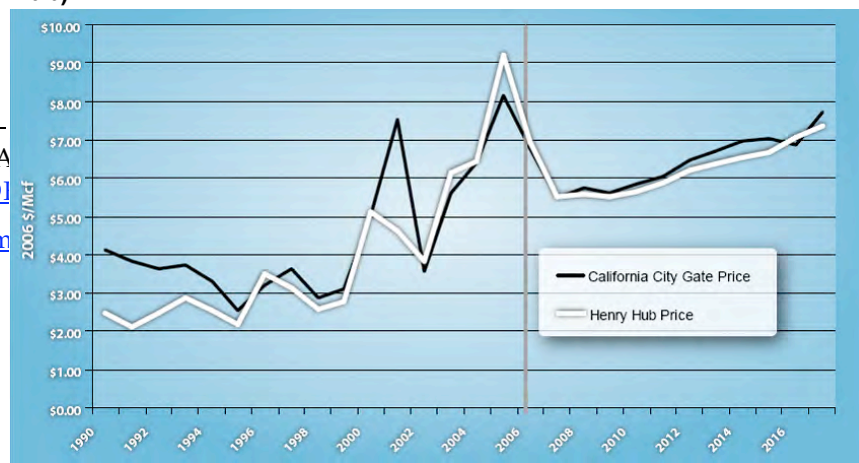
Stimulate Economic Growth in California through Advanced Natural Gas Technologies

Given California's current economic environment, energy research should

⁷ 2007 Net System Power Report, A
[2008-002/CEC-200-2008-002.PDF](http://www.energy.ca.gov/em/2008-002/CEC-200-2008-002.PDF)

⁸ <http://www.energy.ca.gov/em/>

Figure 0: Wholesale Natural Gas Prices (CA compared with Henry Hub)



also focus on projects that help fuel near-term economic growth. For example, projects that directly reduce natural gas costs for end-users through efficiency improvements or more economical alternatives allow natural gas ratepayers to reduce consumption and realize cost savings. In addition to projects that address efficient and clean development of California's natural gas system, this budget proposes a high priority for projects that specifically reduce natural gas costs. This is especially important since the wholesale natural gas price in California is projected to grow at a slightly higher rate compared to the wholesale price (Henry Hub price) based on an Energy Commission staff analysis reported in the 2007 IEPR (Figure 0). Future research will assess the impact these natural gas market factors have on how California businesses and consumers accept and implement new cost reduction technologies.

Identify and Achieve Long-Term Natural Gas Goals for California's Energy-Smart Development

The Energy Commission believes that California's natural gas system will be transformed over the next decade as the state pursues its goal of energy-smart and community-oriented development. The Energy Commission envisions the following developments and opportunities for California's natural gas industry: the supply mix will become significantly diversified using liquefied natural gas (LNG), biogas and other renewable alternatives; natural gas and clean alternatives will become larger components of California's transportation fuel mix; and, the statewide natural gas consumption could be dramatically reduced by implementing community-level natural gas efficiency measures such as CHP and district heating and cooling.

California Policy Guidance

Energy Action Plan Loading Order

The 2008 *Energy Action Plan Update*⁹ articulates a single, unified approach to meeting California's electricity and natural gas needs. The 2008 *Energy Action Plan Update* emphasizes that meeting California's energy policy goals and mandates "requires the cooperation and teamwork of multiple sectors of the California economy, including the electricity, natural gas, and transportation sectors."

The 2008 *Energy Action Plan Update* identifies next steps for the nine major action areas established in previous EAPs, four that guide the Energy Commission's natural gas research effort and would be addressed in the FY 2009-2010 research program:

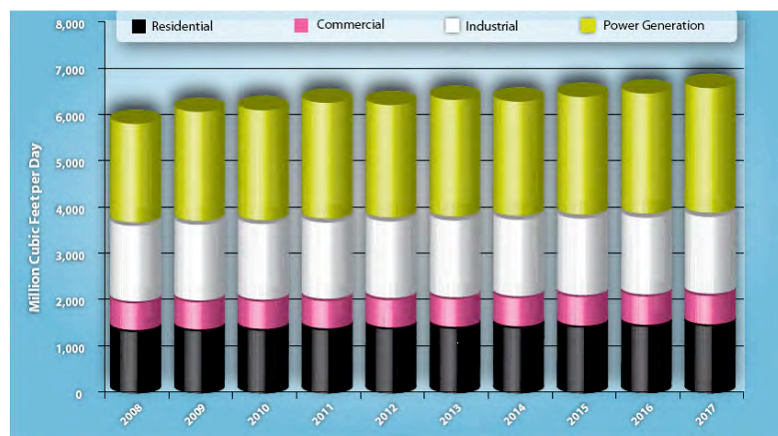
- Energy efficiency
- Renewable energy
- Natural gas supply, demand, and infrastructure
- Climate change

⁹ <http://www.energy.ca.gov/2008publications/CEC-100-2008-001/CEC-100-2008-001.PDF>

2007 Integrated Energy Policy Report

The Energy Commission's 2007 *Integrated Energy Policy Report* (IEPR)¹⁰ is California's key energy policy document, with an update released in 2008. The 2007 IEPR reflects input from the numerous public and private stakeholders and federal, state, and local agencies that participated in the IEPR proceeding, including nearly 50 public workshops and hearings and approximately 70 supporting reports.

Figure 0: Projected California Demand by Sector 2008-2017



The 2007 IEPR details natural gas resource constraints in California and outlines several major issues facing the state's natural gas sector including growing demand (Figure 0), dependence on imports, price fluctuations, and AB 32 policy goals. In response, the proposed natural gas research budget addresses energy efficiency, renewable energy resources, natural gas supply and GHG emissions reduction targets.

State Alternative Fuels Plan

AB 1007¹¹ required the Energy Commission and the Air Resources Board to jointly develop and adopt an implementation plan for alternative fuels. The *State Alternative Fuels Plan* set following policy goals:

- Petroleum reduction
- GHG reduction
- In-state biofuels production and use
- Improved air quality

The *State Alternative Fuels Plan* also provided these findings for natural gas and several alternative fuels:

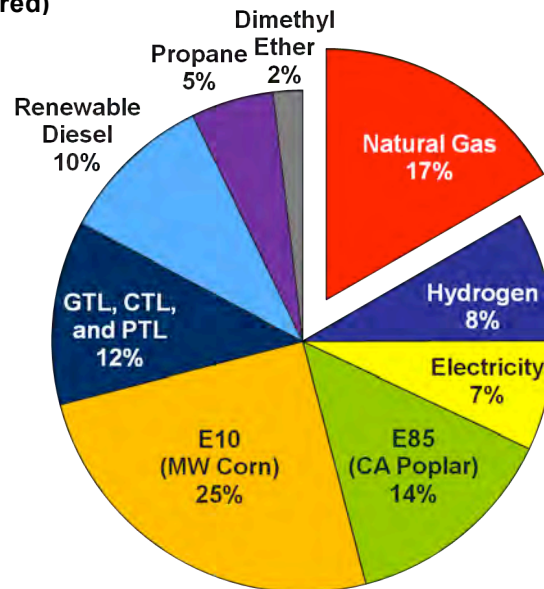
- A number of different analyses examined the penetration of various alternative fuels into the transportation fuel sector using the best available full fuel cycle analysis methodology. A moderately aggressive case showed that ambitious but realistic goals for displacing traditional gasoline and diesel can be achieved. These goals, expressed on a gallon of gasoline equivalent basis, are:

¹⁰ http://www.energy.ca.gov/2007_energypolicy/index.html

¹¹ <http://www.energy.ca.gov/ab1007/index.html>

- 9 percent in 2012
- 11 percent in 2017
- 26 percent in 2022 (Figure 0)
- These goals accelerate the growth of alternative fuels, displacing more than 4 billion gasoline gallon equivalents (20 percent) in 2020. This could grow to at least 30 percent by 2030. By 2050, alternative fuels could provide more than half the energy needed to power California's transportation system.
- Biodiesel and renewable diesel, natural gas, propane, and electric drive technologies are primary options to displace diesel fuel in specific markets, such as transit buses, school buses, delivery vans, truck refrigeration units, and port vehicles.
- Natural gas use in heavy-duty vehicles alone could represent about 36 percent of the freight and off-road vehicle fuel use by 2050.

Figure 0: State Alternative Fuels Plan
Projection of Alternative Fuel Breakdown in 2022 (total volume = 5.3 billion gal. of gasoline equivalent, natural gas-derived solutions in red)



The *State Alternative Fuels Plan* further states that natural gas as a transportation fuel could account for the largest percentage (6.7) of GHG reductions from nine alternative fuels studied.

The transportation research component of the Energy Commission's natural gas research program would develop alternative fuel and vehicle technologies¹² to help achieve the goals of the *State Alternative Fuels Plan*. Research results would target the Alternative and Renewable Fuels and Vehicle Technology Program (ARFTVT)¹³ for market implementation into the marketplace.

Natural Gas Research Priorities and Approaches

Funding Priority Overview

Senate Bill 1250¹⁴ directs the Energy Commission to meet new research investment goals while performing a full range of RD&D not supported by competitive markets. The Energy

¹² Excluding electric drive technology; the Energy Commission's electricity RD&D program will support electric drive RD&D.

¹³ <http://www.energy.ca.gov/proceedings/2008-ALT-1/>

¹⁴ Perata, Chapter 512, Statutes of 2006 (http://www.leginfo.ca.gov/pub/05-06/bill/sen/sb_1201-1250/sb_1250_bill_20060927_chaptered.pdf)

Commission responded by first creating a new research structure for its electricity research program. The structure is comprised of several key categories including transportation, energy efficiency and demand response, advanced electricity generation, renewables, transmission and distribution, and energy and climate science.¹⁵ The Energy Commission also has a similar reporting structure for its natural gas research comprised of the following categories:

- Improving residential, commercial, industrial and transportation energy efficiency.
- Accelerating the adoption of clean alternatives to conventional natural gas resources and technologies.
- Improving natural gas system and infrastructure performance and reliability.
- Reducing the environmental footprint of California's natural gas system.

Figure 4 breaks down the natural gas research program proposed budget for FY 2009-2010. The focus and priorities of the Energy Commission's research effort have remained consistent since the start of the natural gas program, throughout the process of updating the reporting structure, and in this proposed budget. Transportation-related research funding is highlighted in red as it is embedded in several categories and equals almost one-third of the research funding.

Figure 1: Proposed Natural Gas RD&D Budget for FY 2009-2010

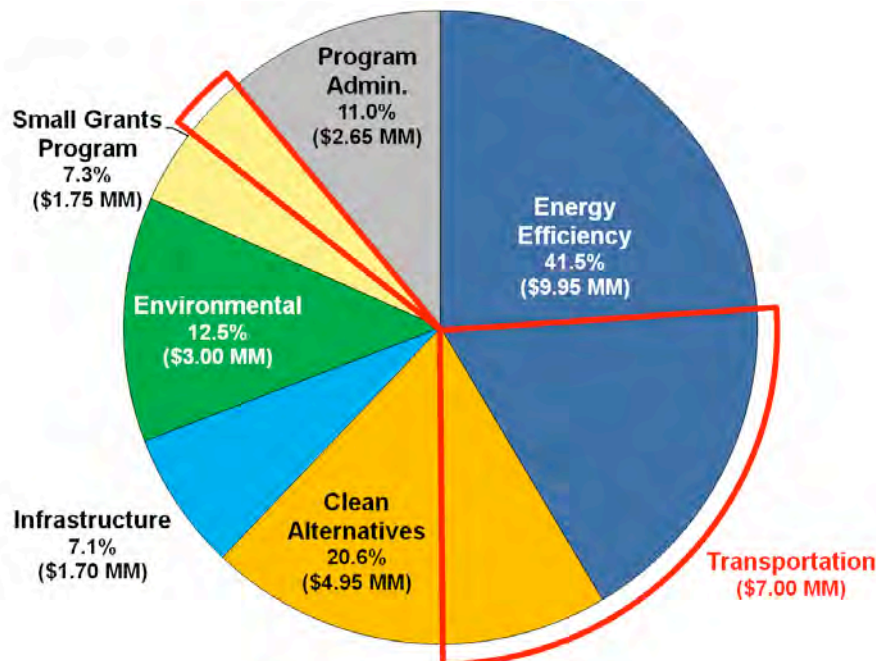


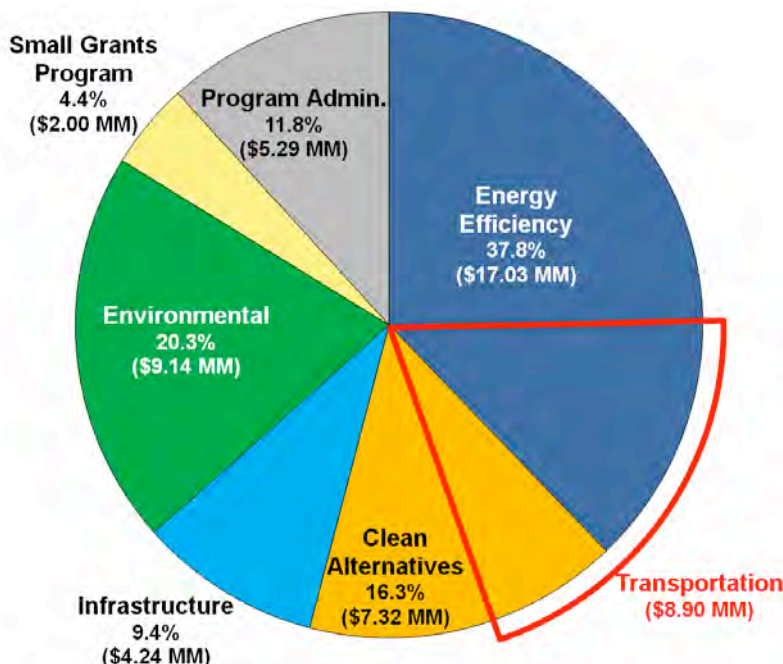
Figure 5 summarizes the Energy Commission's natural gas research expenditures from January 2005 through June 30, 2008¹⁶, using the same categories. The transportation research and the

¹⁵ Public Interest Energy Research Program 2008 Annual Report Draft.

¹⁶ The reporting cycle for the Energy Commission's natural gas RD&D program switched from a calendar year basis to a fiscal year basis effective December 2006 pursuant to Resolution G-3394 (http://docs.cpuc.ca.gov/PUBLISHED/FINAL_RESOLUTION/63130.htm).

Energy Innovations Small Grant (EISG) Program were not a part of the Energy Commission's natural gas RD&D program during its first year.

Figure 2: Total Natural Gas RD&D Expenditures through June 30, 2008



Natural Gas Research Program Research Topic Areas

The loading order for energy resources is ideally suited to advancing strategic development of California's natural gas system. Accordingly, the Energy Commission has identified natural gas research topic areas that would help California meet its natural gas demand consistent with the loading order while continuing to build on other strategic research needs. The research topic areas are:

- Improving residential, commercial, industrial and transportation energy efficiency.
- Accelerate the adoption of clean alternatives to conventional natural gas resources and technologies.
- Improve natural gas system and infrastructure performance and reliability.
- Reducing the environmental footprint of California's natural gas system.

By focusing on these four research topic areas, the Energy Commission's natural gas research program supports a range of issues and concerns critical to California's economic growth, the state's effort to meet its natural gas demand in environmentally sensitive ways and improve its natural gas infrastructure.

Improving Residential, Commercial, and Industrial Energy Efficiency

Natural gas end use and process efficiency is the Energy Commission's highest priority research topic area and one that provides significant near-term benefits to California residents.

Approximately one-third of California's natural gas consumption today is on-site gas use (e.g., water heating, space heating and cooking), and another 30 percent is used for to electricity

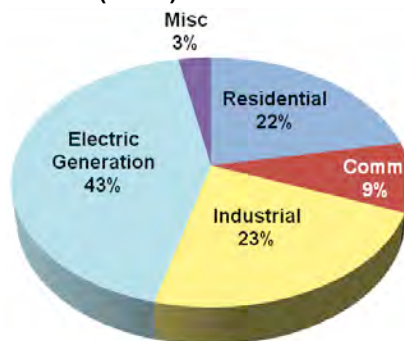
generation for residential and commercial buildings. In total, energy consumption in California's residential and commercial buildings account for more than 60 percent of the total natural gas consumed in the state annually (Figure 2). On-site natural gas use in the industrial sector accounts for roughly another one-quarter of the state's natural gas consumption.

Natural gas use in the transportation sector, currently a small portion of total demand, is expected to increase significantly following implementation of the *State Alternative Fuels Plan* (Plan), AB 32 and other policies. For example, the *Plan* establishes the goals to displace conventional petroleum-based fuels by 9 percent of

total fuel consumption by 2012, and 26 percent by 2022. The *Plan* notes that natural gas use in heavy-duty vehicles alone could represent about 36 percent of the freight and off-road vehicle fuel use by 2050. The disproportionate contribution the transportation sector makes to GHG emissions, due to its almost complete reliance of gasoline and diesel fuels, ensures that the sector becomes a prime target of AB 32. Increased vehicle efficiency would increase the number of natural gas vehicles. The Energy Commission proposes coordinating its transportation research effort with the ARFVT¹³ to bring emerging transportation energy technologies to the marketplace.

The 2008 *EAP Update* and 2007 *IEPR* support all cost-effective energy efficiency measures for natural gas and encourage pursuing energy efficiency improvements through increased natural gas RD&D. The CPUC established a specific state goal of reducing natural gas demand by 290 million therms from investor-owned utility customers between 2005 and 2014¹⁷ (CPUC D04-09-060) from a 2004 baseline of 13,436 million therms¹⁸. The Energy Commission to support these goals and advocates increasing the energy efficiency of existing building systems, industrial processes and transportation end-uses. Examples include reducing and optimizing hot water use in residential, commercial, and industrial operations, and developing more efficient natural gas-fueled medium- and heavy-duty vehicles. The Energy Commission is also working to develop and advance more energy efficient end use technologies and strategies for unique California conditions and industries.

Figure 2: Breakdown of California Natural Gas Consumption by Sector (2007)



- 22% of natural gas used for space and water heating, and cooking in residential buildings
- 10% similarly used in commercial buildings
- 43% of California natural gas used to generate electricity, about 2/3 of which is used in buildings
- Therefore, buildings account for 61% of California natural gas use

¹⁷ D04-09-060 (http://docs.cpuc.ca.gov/published/Final_decision/40212.htm)

¹⁸ *California Energy Demand 2006-2016 - Staff Energy Demand Forecast*, September 2006 (www.energy.ca.gov/2005publications/CEC-400-2005-034/CEC-400-2005-034-SF-ED2.PDF)

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

The Energy Commission believes renewable natural gas alternatives, and highly efficient applications of natural gas, such as CHP, require immediate and continued research to ensure significant long-term benefits for California's natural gas ratepayers. The demand for natural gas for electricity generation and commercial and residential heating applications is increasing and expected to increase for transportation-related uses as well. Renewable resources that could displace conventional natural gas are abundantly available in California, although many of these options require long-term research to support their development and market entry. The transportation sector, which is expected to rely more on natural gas for important niche applications, would benefit from research into alternative fuels that could be substitutes for conventional natural gas.

California energy policies and directives prioritize reducing the state's dependence on imported natural gas through diversification of its gas supplies. For instance, the *2008 Energy Action Plan Update* recognized the need for additional research to establish or improve the viability of these natural gas alternatives, particularly solar thermal technologies. Similarly, the *2007 IEPR* encouraged utility preference for low-carbon fuels, including renewables for electricity generation and alternative resources that directly displace natural gas, such as solar for water and space heating or pipeline-quality injected biogas. Already working to expand the market acceptance of CHP and combined cooling, heating and power (CCHP) systems to reduce the natural gas and electricity costs, the Energy Commission proposes pursuing research that would work to reduce the cost and improve the performance of solar thermal, biogas, and geothermal technologies. Another important research initiative would be developing renewable natural gas alternatives such as fuel produced from landfill gas.

Improve Natural Gas System and Infrastructure Performance and Reliability

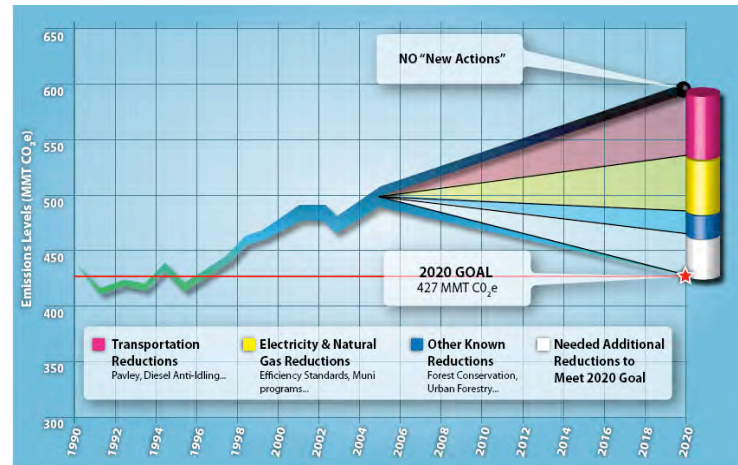
The safety and security of the state's gas infrastructure are important priorities for California. The state's aging natural gas infrastructure, coupled with its growing gas demand, represent significant challenges that would affect California's natural gas ratepayers and stakeholders. Furthermore, natural gas is expected to serve an increasingly important role as a back-up to intermittent renewable electricity generators. Increasing need and demand for renewable generation in California's electricity market will result in increased interdependencies between the state's natural gas and electricity systems. Additionally, diverse customer behaviors and responses to various market conditions must be considered to better characterize optimal system operations.

The *2008 EAP Update* and the *2007 IEPR* advocate policies that allow California to secure alternative and diverse sources of natural gas to meet growing demand and provide energy security, such as LNG. To address the concerns that do not directly fall under energy efficiency or renewable energy categories, the Energy Commission's natural gas research program intends to place increasing emphasis on capturing the synergies between natural gas system and the California Smart Grid to leverage efforts to fulfill both renewable portfolio standard (RPS) goals and GHG reduction targets.

Reducing the Environmental Footprint of California's Natural Gas System

The Energy Commission believes research efforts that reduce the environmental footprint of California's natural gas system are critical to the successful adoption of emerging natural gas technologies. California's natural gas system must be expanded and improved in compliance with state and federal regulations that protect natural resources and minimize environmental, health and safety hazards. The power plant GHG Emissions Performance Standards established by the CPUC Decision 07-01-039¹⁹ heightens the importance of natural gas in meeting the state energy policy goals. An environmentally sound natural gas system is crucial for California to achieve the long-term GHG emissions reductions target defined by AB 32 (Figure 2).

Figure 2: State GHG Emissions Projection and Needed Reductions to Meet AB 32



The 2008 Energy Action Plan

Update supports collaboration among the CPUC, the Energy Commission and the Air Resources Board to determine how electricity and natural gas sectors should be included in AB 32 framework. The *Proposed Final Opinion on Greenhouse Gas Regulatory Strategies* provides directions and priorities on how to achieve these AB 32 reduction goals. The 2007 *IEPR* points out that AB 32 places reducing GHG emissions at the center of California's government and business agendas, and highlights additional research needs that must be addressed in order to meet the AB 32 goal. Furthermore, The Energy Commission's natural gas research program is evaluating and characterizing the impact of California's natural gas system on the climate, as well as other environmental impacts associated with various natural gas technologies.

¹⁹ http://docs.cpuc.ca.gov/published/FINAL_DECISION/64072.htm

CHAPTER 2:

Fiscal Year 2009-2010 Research Plan

Overview

The Energy Commission's *Proposed Program Plan and Funding Request for Fiscal Year 2009-2010 (Natural Gas Budget Plan)* reflects current state energy policy, particularly the loading order introduced in the *2008 Energy Action Plan Update*. The *Natural Gas Budget Plan* incorporates emerging issues from energy trends and drivers, synthesized into four main research areas:

- Improve residential, commercial and industrial energy efficiency.
- Accelerate the adoption of clean alternatives to conventional natural gas resources and technologies.
- Improve natural gas system and infrastructure performance and reliability.
- Reduce the environmental footprint of California's natural gas system.

The *Natural Gas Budget Plan* is \$24 million, and includes program administration, small grants, and research project funding. Of this amount, \$19.60 million would be spent on specific research areas and an additional \$1.75 million for Energy Innovations Small Grants, which funds feasibility studies for emerging natural gas technologies. A breakdown of the *Natural Gas Budget Plan* by the research topic areas and other budget items is displayed in Table 2 below:

Table 2: FY 2009-2010 Natural Gas Budget Plan Summary

Research Topic Areas	Budget (\$MM)
Improving Residential, Commercial and Industrial Energy Efficiency	\$9.95
Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas System and Infrastructure Performance and Reliability	\$4.95
Improve Natural Gas Systems and Cooling Solutions for Commercial Buildings	\$1.70
Reducing the Environmental Footprint of California's Natural Gas System	\$3.00
Energy Innovation Small Grants Program	\$1.75
Program Administration	\$2.65
TOTAL	\$24.00

Proposed Research Solutions

The Energy Commission's natural gas research program aims to help California meet its natural gas demand in a manner consistent with the loading order and key state policies and directives. The four research areas developed by the Energy Commission to carry out these goals address energy efficiency, renewables and clean alternatives, infrastructure, and the science of energy and climate. Policy guidance for these initiatives extends from the loading order, the *State Alternative Fuels Plan* ¹¹ and AB 32.

Improving Residential, Commercial, Industrial and Transportation Energy Efficiency

As laid out in the 2008 *Energy Action Plan Update*, energy efficiency is the first priority under the state energy loading order. Efficiency improvements through improved building codes, appliance standards, utility energy efficiency programs, and smart growth strategies account for nearly one-quarter of the emissions reductions identified in the *California Climate Action Team Report*²⁰. Transportation energy efficiency will be increasingly necessary and strategic as fuels shift away from gasoline and diesel. The Energy Commission proposes to focus heavily on natural gas RD&D that will improve energy efficiency in California's residential, commercial, industrial, and transportation sectors. The research effort in this area identifies and addresses opportunities to achieve greater energy efficiency benefits with existing or near market-ready technologies. Some of the Energy Commission's work in this area ties back to the water-energy nexus, which was highlighted in the 2005 *IEPR* as a key focus area. The energy embedded in the extraction, transportation, purification, distribution, wastewater treatment and end-use of water accounts for about nine percent of the state's natural gas-fired electricity consumption and one-third of non-power plant natural gas consumption.²¹

In FY 2009-2010, the Energy Commission proposes to leverage knowledge gained from its past and ongoing research to target energy efficiency opportunities with strong potential for significant natural gas savings. Table 3 provides the budget breakdown for FY 2009-2010 for this research area.

Table 3: Budget Breakdown for Improving Residential, Commercial and Industrial Energy Efficiency

Research Solution	Budget (\$MM)
Energy Efficient Food Service Operations	\$1.60
Energy Efficient Hot Water Distribution	\$1.80
Advanced Distribution Systems for Residential Heating	\$0.50
Emerging Technology Demonstration Program	\$0.40
Natural Gas Efficiency Research for Industrial & Institutional Use	\$1.40
Develop and Demonstrate Advanced Fuel-efficient Transportation Technologies and Fuel Switching Strategies	\$4.25
TOTAL	\$9.95

Energy Efficient Food Service Operations

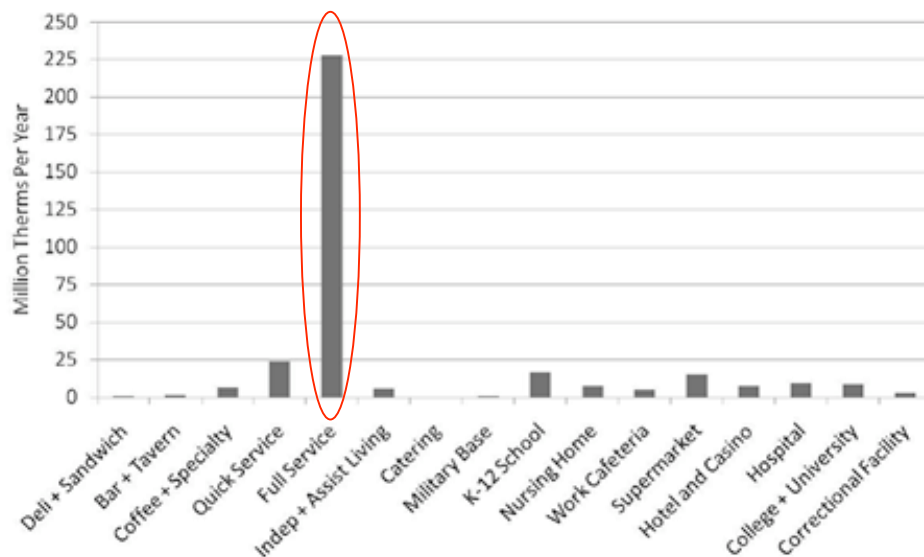
Gas use in full-service commercial food facilities has been identified as an area that could benefit significantly from efficiency improvements. Full-service facilities in California collectively account for over 60 percent of natural gas use by all of the state's food service facilities, including hospitals, universities and hotels (Figure 3). Much of the potential efficiency gain would come from improvements in hot water heating and range-top cooking. On a daily basis, each of California's 34,400 full-service facilities uses an average of 2,000 gallons of hot water.

²⁰ http://www.climatechange.ca.gov/climate_action_team/reports/index.html

²¹ 2005 *IEPR*, Chapter 8: Integrating Water and Energy Strategies, 139.

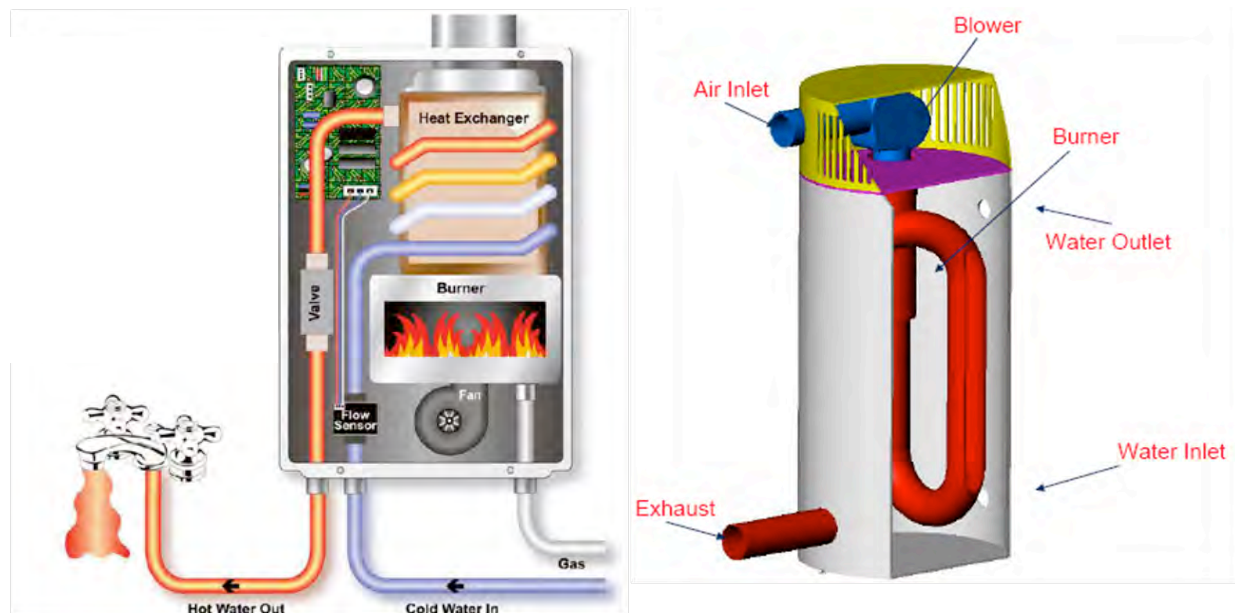
As much as 80 percent to 90 percent of the energy used to heat that water literally goes down the drain.

Figure 3: Annual Food Sector Gas Load by Service Facility Types (full service facilities in red)



Examples of research the Energy Commission would fund include development of a water-to-water and air-to-water heat exchanger for dishwashers; development of advanced gas-burner range; demonstration of restaurant-specific refrigeration heat recovery for preheating water; and, testing of tankless and high efficiency condensing water heaters for restaurant applications (Figure 4).

Figure 4: Schematics of a tankless (left) and high-efficiency condensing water heater (right) for commercial applications



Energy Efficient Hot Water Distribution

The Energy Commission has found through its past natural gas research efforts that heat loss in water distribution systems is one of the biggest inefficiencies in California's residential and commercial water heating systems. Various studies suggest that improvements in hot water distribution system design could improve efficiency by up to 50 percent while reducing hot water delivery time. In particular, the Energy Commission proposes to support field assessment of tankless water heaters in both residential new construction and retrofit applications; test heat exchangers that use second story shower grey water to preheat incoming cold shower water; and assess flow, pressure and customer satisfaction of a range of showerheads currently available to consumers.

Advanced Distribution Systems for Residential Heating

Residential space heating represents a significant end use for natural gas. The Energy Commission intends to fund advanced research on hydronic radiant space heating for use in floor systems, radiators, fan coil units and fin-tube baseboard convectors. Hydronic heating includes all types of hot water heating and can be used in a wide variety of applications. This flexibility allows for a high level of temperature control within the heated area, making homes comfortable at lower air temperatures due to elevated mean radiant temperature, the lack of significant airflow and delivery of heat at floor level. Corresponding efficiency benefits are realized through lower thermostat settings, lower temperature boiler/water heater settings, and reduced infiltration. Evenly distributed heat from a radiant floor heating system may allow the thermostat to be set for 2-4 °F below the level needed for a forced air heating system.

Natural Gas Efficiency Research for Industrial and Institutional Use

As the primary method of heat delivery for California industry, which accounts for 25 percent of the state's natural gas consumption, natural gas efficiency in industrial applications is very important. The Energy Commission proposes to fund technologies such as high efficiency, low emission burner designs; burners with integrated heat recovery systems; components to optimize

heat recovery (valves, intelligent cycling system); combustion control systems; flexible fuel boilers; fuel switching, mixing and use without adversely affecting process performance; new techniques for process heating; renewable resources to displace natural gas; and software tools for process optimization and monitoring. The Energy Commission is currently evaluating proposals for research and development of sealing systems for heating system openings, redesigned thermal processes and equipment for reduced air leakage, and corrosion-resistant materials for waste heat streams.

Emerging Technology Demonstration Program (near term demos/eligible for rebates)

Emerging technologies are needed to advance efficiency beyond currently available technology, which will eventually reach a saturation point. The Energy Commission is evaluating project proposals for research and development of high temperature regenerative burners that can be used with high O₂ air input or oxy-fuel burners for glass melting applications and analysis tools for oxy-fuel combustion, radiation losses, high temperature heat recovery and electric boost for glass melting applications.

Develop and Demonstrate Advanced Fuel-Efficient Transportation Technologies and Fuel Switching Strategies that Result in a Cost-Effective Reduction of On-Road and Off-Road Petroleum Fuel Use in the Short and Long Term

The Energy Commission believes that natural gas vehicles will play an important role in realizing California's goals for cleaner transportation. Key research areas for advancing natural gas vehicles include improved efficiency, technical limitations and infrastructure improvements. The *Natural Gas Vehicles Research Roadmap*²² completed in 2008 identifies several initiatives and projects that pursue the research, development, demonstration and deployment of advanced fuel-efficient natural gas applications (Figure 10).

Not intended to compete in the traditional on-road light-duty vehicle market, the value of natural gas vehicles lies in their potential application to specific niche markets such as medium- and heavy-duty vehicles, most frequently belonging to fleets and/or for use off-road. Natural gas may also serve as a key co-fuel for advanced model plug-in hybrid electric vehicles (PHEVs).

²² <http://www.energy.ca.gov/2008publications/CEC-500-2008-044/CEC-500-2008-044-D.PDF>

Figure 10: Recommended Funding Priorities from the Natural Gas Vehicle Research Roadmap (Issues addressed by FY 2009-2010 research circled in red)

		Top Priorities	Second-Tier Priorities	Longer-Term Priorities
Near Term	Engine Development and Vehicle Integration	More heavy- and medium-duty engine/vehicle integration	More line haul heavy-duty engine/vehicle choices	Light-duty vehicle choice expansion
		More heavy-duty and medium-duty engine sizes	Certification of new models	Continued engine refinements
		Existing heavy-duty and medium-duty engine improvements		HCNG and HCCI engines/verifications
			Determine and develop the controls for emissions due to fuel variability and stricter GHG (i.e., methane) standards.	
Longer- Term	Fueling Infrastructure and Storage	Develop legacy fleet engine controls and/or repower/retire programs to accommodate fuel variability		
		Fueling ease/standards for CNG and LNG	GPS-based station locator/information portal	
			On-board fuel tank economies	Low-pressure on-board fuel storage
		Fueling station economies	Modular fueling stations	Non-traditional station sites
Near Term	Technical and Strategic Studies	CNG & LNG vehicle database	Codes and protocol studies/changes	
		Fleet business case models	Public station economies	Insurance economies
		Technical roadmap update panel		
Longer- Term				

Investment in fuel-efficient and fuel-switching transportation technologies will improve overall natural gas efficiency and enable the advancement of natural gas vehicles. The Energy Commission proposes supporting research to expand vehicle market choices by advancing integration of medium- and heavy-duty vehicles through efficient engines, engine sizes and combustion concepts. The Energy Commission would also fund research on the development of flexible fueling capability for LNG. Specifically, the Energy Commission seeks to support research that will lower the cost of the fueling infrastructure. Transportation efficiency research has the dual benefit of direct (vehicle) and indirect (electricity grid) conservation of natural gas.

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

The state loading order ascribes second highest priority to renewable resources and other clean alternatives including CHP. California's Renewable Portfolio Standard assigns a high priority to reducing the state's dependence on imported natural gas by diversifying its gas supplies. The

availability and stability of natural gas supply affects prices and price volatility. The demand for natural gas is increasing for electricity generation, commercial and residential heating applications, and transportation end-uses. Additional research is needed to guide future policy on regulation of new natural gas markets and maintaining infrastructure quality. Resource availability, demand trends, and regulatory framework are key drivers in this area.

Renewable resources that could displace conventional natural gas are abundantly available in California. The Energy Commission believes renewable natural gas alternatives, as well as highly efficient applications of natural gas such as CHP, require immediate and continued research for them to result in significant long-term benefit to California's natural gas ratepayers. Proposed research in this topic area would address the following IEPR recommendations:

- Support to displace natural gas with renewable sources to generate electricity and alternatives such as solar for water and space heating.
- Identify energy storage technologies such as high temperature thermal energy storage in solar thermal power plants with the most promise to resolve grid stability and operations issues related to higher penetrations of renewables, reduce the costs of those technologies, analyze their integration with solar and wind power plants, and accelerate their commercialization.
- Address technical and infrastructure barriers to deployment of emerging renewable heating and cooling technologies and to assess their current and future cost trajectories as well as how to strengthen the market for commercially mature technologies.
- Develop natural gas alternatives and substitutes for use within transportation applications, ideally utilizing existing infrastructure and vehicles.

In supporting these recommendations, the Energy Commission proposes targeting four areas: buildings-scale, community-scale, and utility-scale implementation, and alternative transportation fuels. Table 4 provides the proposed budget breakdown for FY 2009-2010 for this research area.

Table 4: Budget Breakdown for Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

Research Solution	Budget (\$MM)
Natural Gas-Fired and Waste Heat-Augmented Heating/Power Systems and Cooling Solutions for Commercial Buildings.	\$0.45
Develop Energy Efficient, Cost Effective, Safe, Clean, Durable, and Reliable CHP and Distributed Energy Resources Technologies.	\$1.00
Develop Low-cost and Thermally Efficient Energy Storage System for Concentrating Solar Power.	\$1.50
Research, Develop, and Deploy Alternative Fuels that Reduce Petroleum Consumption and Transportation-related GHG Emissions, While Assisting Economic Development within the State of California.	\$2.00
TOTAL	\$4.95

Natural Gas-Fired and Waste Heat-Augmented Heating/Power Systems and Cooling Solutions for Commercial Buildings

CHP and CCHP are integrated systems that can provide these multiple products with one energy input. Almost all energy-related processes waste some energy, often in the form of heat. CHP and CCHP systems capture the waste heat released by gas power generators or engine-driven chillers and can be used to run cooling equipment such as desiccant dehumidifiers or absorption chillers, or to run space or water heaters. The energy efficiency of these systems is being recognized by building managers seeking to reduce energy costs and by government officials with environmental objectives.

The Energy Commission views CHP / CCHP systems as one of the key natural gas research topics given its superior efficiency (some exceed an 80 percent overall efficiency). The Energy Commission intends to pursue research activities that will improve the feasibility and cost performance of novel CHP / CCHP applications that leverage renewable resources as supplemental input along with natural gas. In particular, the Energy Commission plans to fund a study to examine CHP application powered by natural gas and waste heat in commercial buildings, and a study on commercial absorption cooling using natural gas in combination with waste heat and solar thermal energy as an input.

Develop Energy Efficient, Cost Effective, Safe, Clean, Durable, and Reliable CHP and Distributed Energy Resources Technologies

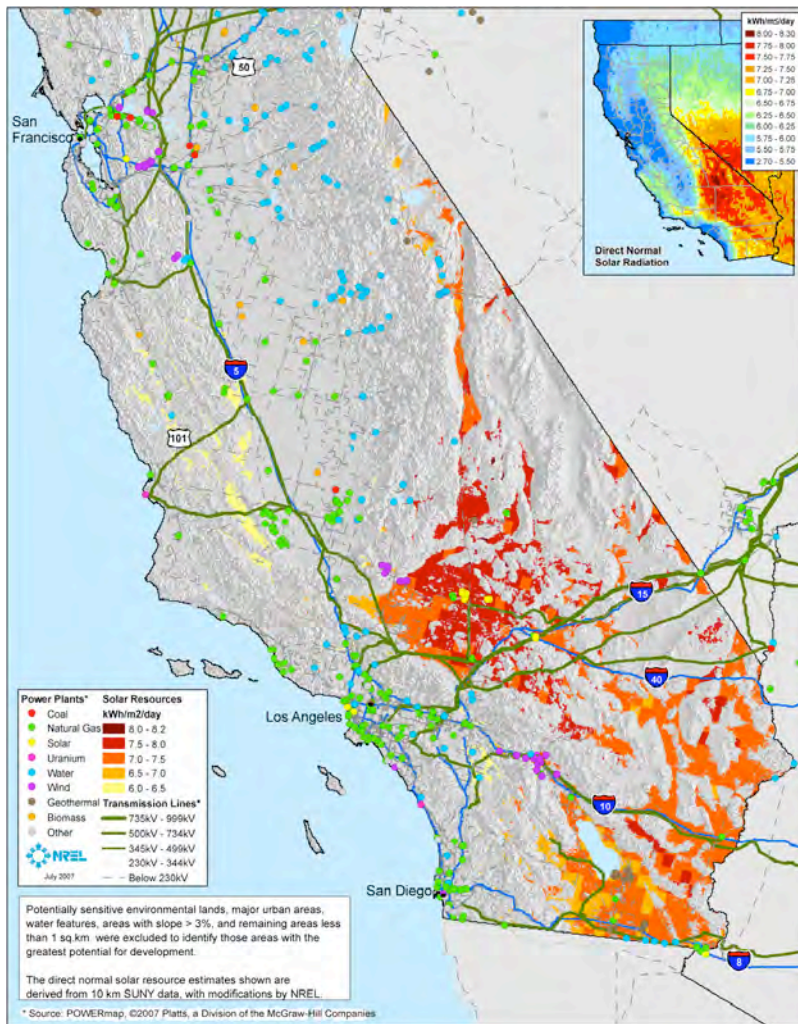
Energy efficient, durable and reliable distributed energy resources systems are a promising solution to California's need for cost effective, safe and clean energy technologies and GHG emission reductions. Two forms of distributed energy resources technology, CHP and CCHP systems, will be particularly important going forward because of their high thermal and electric system efficiency. Nevertheless, a barrier to the advancement of CHP / CCHP in California is the poor emissions performance of reciprocating or internal combustion engines for these applications. As part of its advanced generation research, the Energy Commission proposes developing low-emission technology for internal combustion or reciprocating engines for CHP applications with inverter-based power. The technology would target low emissions of both criteria pollutants and GHG. Research funded by the Energy Commissions would seek to utilize

alternative fuels with low carbon intensity such as biogas, flared gas and natural gas coupled with inverter-based power and smart grid integration. These efforts would involve design, testing and field evaluation and monitoring.

Develop Low-cost and Thermally Efficient Energy Storage System for Concentrating Solar Power

Solar thermal technology is one of the potential renewable resources that could reduce or displace consumption of natural gas. This research will allow California to replace natural gas fired power plants with clean renewable resources. The Energy Commission is currently funding a field assessment and demonstration of emerging solar CHP technology for institutional application (see program highlights for more specific details). To complement this buildings-scale research effort, the Energy Commission intends to design and develop utility-scale energy storage system for concentrating solar power (CSP) plants that are low-cost and thermally efficient. These thermal energy storage systems would allow power to be dispatched to meet system peak load. This project can lead to dispatching power without hybridizing the system with natural gas or other fossil fuels, and can significantly increase the value of the power, while leveraging abundantly available solar thermal resources in southern California (Figure 5). The thermal energy storage system that would be developed could also be leveraged in applications beyond solar thermal plants to further reduce natural gas use.

Figure 5: Concentrating Solar Power Prospect of California



Research, Develop and Deploy Alternative Fuels that Reduce Petroleum Consumption and Transportation-Related GHG Emissions, While Assisting Economic Development within the State of California

The *Alternative Fuels Research Roadmap* effort began in 2007 with the convening of a working group comprised of key stakeholders from industry, regulatory agencies and Non-Governmental Organizations. The working group divided this research area into three categories: (1) resources and upstream, (2) fuel processing and conversion, and (3) distribution and fuel infrastructure. Gap analysis for the Alternative Fuels Research Roadmap has started and should be completed in April-May 2009.

The Energy Commission intends to support research on substitutes for petroleum fuels. Ideally, these substitutes would be fungible with conventional fuels so that they might utilize existing transmission and distribution infrastructure and avoid requiring vehicle modifications. The Energy Commission intends to support smaller scale integrated niche solutions that: (1) address multiple issues simultaneously within the context of alternative fuels production and (2) are not intended to displace major market shares of conventional fuels. Examples of ideal projects

include research into municipal solid waste-to-energy, landfill gas, dairy waste-to-energy, and overcoming barriers to successful deployment including feedstock availability, feedstock treatment, process energy balances and process environmental impacts.

Improve Natural Gas System and Infrastructure Performance and Reliability

The loading order directs that the improvement of the electricity transmission and distribution infrastructure must be undertaken to achieve improvements in energy efficiency and successful integration of clean generation. As natural gas continues to be a significant part of California's generation mix at both the transmission- and the distribution-levels, natural gas systems infrastructure must be optimized to achieve effective integration of California's energy systems. The Energy Commission proposes to continue to focus its systems integration research to identify and optimize the synergies between California's natural gas systems and the emerging Smart Grid technology solutions. Research in this topic area would address the following IEPR recommendations:

- Obtain a robust assessment of the effect of high levels of preferred resources on reducing natural gas prices.
- Integrate distribution planning with other resource procurement processes to support the use of new low-carbon resources and applications — renewables, demand response, efficient combined heat and power, distributed generation, energy storage, advanced metering infrastructure, and plug-in hybrid electric vehicles.
- Improve the ability to forecast natural gas production, demand, and price, including:
 - Conducting a rigorous verification of the models used to forecast natural gas supply and price.
 - Developing probabilities and quantifying outcomes for demand scenarios to gain better insight into natural gas demand.
- Increase natural gas research and development for ways to advance energy efficiency for both consumers and power plants.
- Evaluate the effects of increased use of renewables and of changes in regional natural gas markets on natural gas demand and price in California.
- Evaluate the availability of natural gas in California based upon different scenarios and increasing worldwide demand.
- Estimate potential cost impacts of the 33 percent RPS target based on current contracts and scenarios.

Table 5 provides the budget breakdown for FY 2009-2010 for this research area.

Table 5: Budget Breakdown for *Improve Natural Gas System and Infrastructure Performance and Reliability*

Project Title	Budget (\$MM)
Integration of Smart Grid Technologies	\$1.00
Improve Understanding of Consumer Behavior and Market Issues	\$0.70
TOTAL	\$1.70

Integration of Smart Grid Technologies

Aging natural gas infrastructure in California, coupled with dramatic changes in supply and demand of natural gas, poses a significant challenge for the state's natural gas ratepayers and stakeholders. The Energy Commission proposes supporting research to enable a modernized and secure natural gas infrastructure operations and maintenance that would enhance reliability of California's natural gas delivery system. A major part of this effort would involve developing various demand scenarios based on possible policy and supply-side considerations through rigorous modeling. In particular, the Energy Commission would identify and evaluate opportunities for natural gas infrastructure upgrades in the context of Smart Grid technology implementation (e.g., increase in gas demand from high penetration of gas-powered distributed generation, and a greater demand for gas storage to back up high penetration of intermittent renewable resources).

Improve Understanding of Consumer Behavior and Market Issues

Consumer awareness and response are crucial element to the successful implementation of energy systems upgrades and modernization. The Energy Commission has conducted a consumer survey and utility bill (and weather) data collection for a sample of residential natural gas customers in northern and southern California. The Energy Commission would use the data collected to better understand consumer behavior and response to various market conditions (e.g. price volatility) as well as other measures and considerations that may affect their gas usage pattern (e.g. energy efficiency incentives with enabling technologies). This study would also consider the nexus between electricity and natural gas to identify promising research objectives and initiatives in the area of systems integration going forward. This effort would support the development of effective strategies to advance energy efficiency for both natural gas and electricity end users in California.

Reducing the Environmental Footprint of California's Natural Gas System

Reduction of GHG emissions is one of the most significant policy mandates for California today. Most importantly, AB 32 places a direct, statewide cap on GHG emissions and requires California to reduce its GHG emissions to 1990 levels by 2020. This legislation includes emissions associated with California's natural gas system and will require substantial efficiency and optimization of natural gas end uses, especially those that burn natural gas for heating and various industrial processes. Furthermore, urban development and pressures of growing economy and population affect sensitive habitats, air quality, and water quality. Applying existing regulations and any new environmental protection regulations will have impacts on energy infrastructure constraints, energy prices, and protection of the environment, public health, safety, and environmental justice. These policy and regulatory directives require that further development of California's natural gas systems will not increase its environmental

footprint. The Energy Commission proposes supporting research projects that support energy-smart development of California's natural gas system without significantly impacting the state's environment and climate. Table 6 provides the budget breakdown for FY 2009-2010 for this research area.

Table 6: Budget Breakdown for Reducing the Environmental Footprint of California's Natural Gas System

Project Title	Budget (\$MM)
Improve the Understanding of and Develop Solutions to Reduce Impacts from Natural Gas.	\$1.50
Develop Strategies to Reduce Direct and Indirect GHG Emissions Associated with Natural Gas.	\$0.70
Create Tool for Assessing the Impacts of Global Climate Change.	\$0.80
TOTAL	\$3.00

Improve the Understanding of and Develop Solutions to Reduce Impacts from Natural Gas

In the California Air Resources Board Report to the Legislature on Indoor Air Pollution in California, they identified pollutants from combustion appliances as a high priority source category for mitigation.²³ Indoor air pollution is estimated to cost California up to \$45 billion/yr, and is a major detriment to air quality, public health and environmental justice. The Energy Commission's research projects in this topic area would evaluate impacts of natural gas combustion devices in indoor settings which are a major contributor to illness and death from indoor air pollution. These projects would study whole house systems to reduce home carbon monoxide levels and identify co-benefits such as increased energy efficiency, reductions in other pollutants and GHGs. As proposed, this topic area would examine the potential risks to California's groundwater from geologic sequestration of GHG emissions associated with industrial natural gas combustion.

Develop Strategies to Reduce Direct and Indirect GHG Emissions Associated with Natural Gas

As a source of over 78 million tons of CO₂ annually, natural gas combustion is a major source of California-based GHG emissions.¹⁸ The AB 32 Scoping Plan²⁴ specifically identifies the reduction of GHG emission from natural gas combustion as an area of significant concern. To address these concerns, the Energy Commission would support research projects to identify best management practices for addressing direct and GHG emissions from natural gas usage, with a specific focus on carbon sequestration. The AB 32 Scoping Plan has identified carbon sequestration as a strategy which holds significant potential for GHG emissions mitigation. At present, there are few established guidelines for maximizing benefits from sequestration. The projects in this category would help to develop feasible, high-value strategies to help mitigate

²³ Air Resources Board (ARB) Report to the Legislature on Indoor Air Pollution in California, July 2005, <http://www.arb.ca.gov/research/indoor/ab1173/rpt0705.pdf>

²⁴ <http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm>

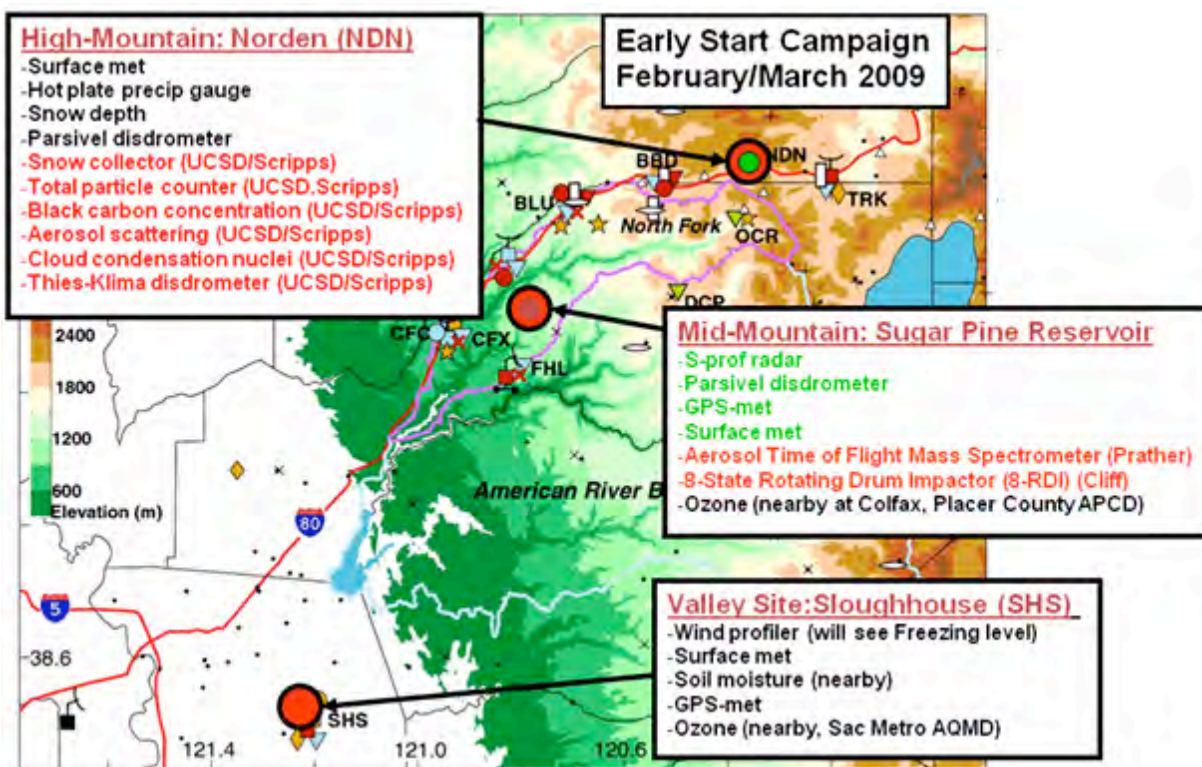
and reduce natural gas-associated GHG emissions through the study of sequestration on California's rangelands, which make up 40 percent of the state's land area.

Create Tool for Assessing the Impacts of Global Climate Change

Understanding the impacts of global climate change on a local level will help to develop efficient mitigation strategies and focus on technologies that have concrete applicability. California's unique climate and geography create an ideal laboratory to study specific climate phenomena and their effect on key state sectors. The Energy Commission intends to use targeted research to better understand the impacts of global climate change on the local California environment. A major part of this effort would be a collaborative study between the Energy Commission, National Oceanic and Atmospheric Administration and several major research universities to explore the atmospheric mechanisms which contribute to statewide influencing Sierra Nevada snowfall

Figure 6). State water supplies replenished by Sierra snowpack are a critical resource for California residents, businesses and industries.

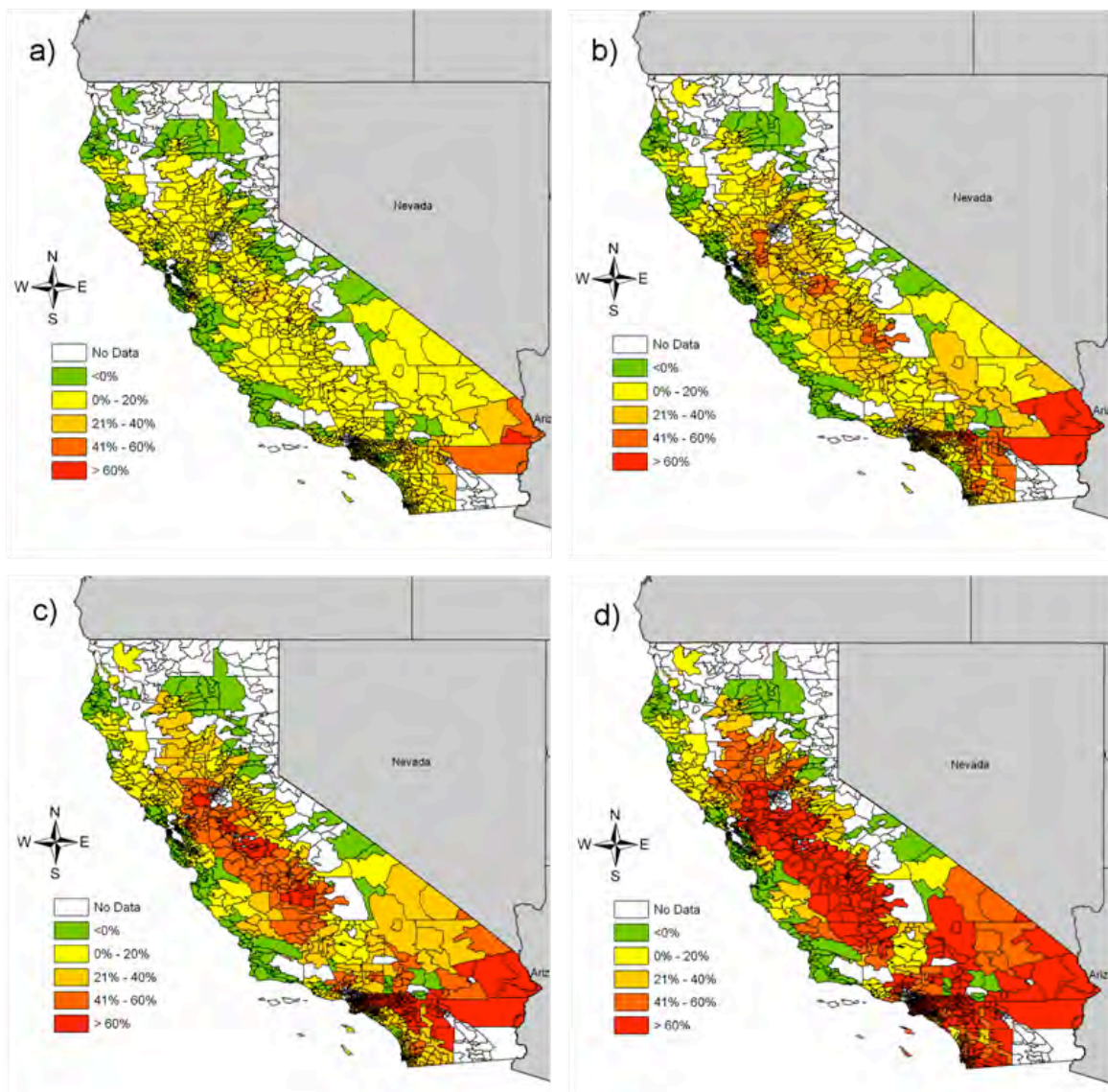
Figure 6: Example of instrumentation that would be deployed for CalWater



Understanding the impacts of global climate change on a local level will help to develop efficient mitigation strategies and focus on technologies that have concrete applicability. California's unique climate and geography create an ideal laboratory to study specific climate phenomena and their affect on key state sectors. The Energy Commission intends to use targeted research to better understand the impacts of global climate change on the local California environment. A major part of this effort would be a collaborative study between the Energy Commission, National Oceanic and Atmospheric Administration and several major research universities to explore the atmospheric mechanisms which contribute to statewide

influencing Sierra Nevada snowfall (Figure 7). State water supplies replenished by Sierra snowpack are a critical resource for California residents, businesses and industries.

Figure 7: Simulated increase in household electricity consumption by ZIP code for the periods 2020-2039 (a), 2040-2059 (b), 2060-2079 (c), and 2080-2099 (d) in percent over 1980-1999 simulated consumption. Model NCAR PCM forced by IPCC SRES A2.²⁵



²⁵ Anin Aroonruengsawat and Maximilian Auffhammer, *Impacts of Climate Change on Residential Energy Consumption: Evidence from billing Data*, DRAFT Final PIER Report, UC Berkeley.

CHAPTER 3:

Long-Term Program Outlook

The Energy Commission intends to continue to evaluate and calibrate its natural gas research portfolio to best provide benefit to California's natural gas ratepayers and other stakeholders. Central to this effort is a renewed focus on quantifying the benefits of the Energy Commission's research activities, and to identify and address emerging long-term natural gas-related themes and trends that are critically relevant to California's energy-smart future.

Quantifying Natural Gas Research Benefits

While the costs and benefits of commercially available products and technologies can be readily quantified, the same is not true for pre-market emerging technologies. Calculating benefits associated with energy technology research can be especially challenging given that some are not readily quantifiable, such as the environmental impact of GHG mitigation and reduction. Nevertheless, the Energy Commission strives to identify and pursue research projects that provide significant and measurable benefit to California's electricity and natural gas ratepayers. The Energy Commission is rigorously evaluating its broader research program by first examining past projects and then applying lessons learned to the evaluation and prioritization processes for future programs.

The costs and benefits evaluation of its electricity program has already started and the Energy Commission plans to initiate the process for its natural gas research program this year. Once the benefits assessment is underway for both programs, the Energy Commission plans to take an integrated approach to evaluating the benefits of its electricity and natural gas research activities. Through this integrated approach, the Energy Commission can more accurately quantify synergistic benefits between the two research programs, enabling more effective research planning strategies going forward.

Energy Loading Order and the State Alternative Fuels Plan

Heavy dependence on petroleum fueled automobiles and a large, growing population represent the key components of the transportation challenge. The absence of viable, market-ready, and cost-effective alternatives to petroleum-fueled automobiles confounds the issue. As a result, California's transportation sector, which already represents 40 percent of the state's total energy demand, is also responsible for a disproportionate share of the state's GHG emissions and petroleum dependence. The transportation component of the Energy Commission's natural gas research program encompasses a wide range of possible initiatives spanning everything from infrastructure to land use and fuels science. This breadth and depth dictate a broad range of research activities exploring multiple possible alternatives to today's inefficient, petroleum-fueled automobiles.

The *State Alternative Fuels Plan* views natural gas as a key alternative fuel in creating a workable transportation sector for California, and outlines the expansion of natural gas in transportation applications. Not intended to compete with conventional transportation fuels or even with many other alternative fuels currently being developed, natural gas is instead envisioned as an ideal fuel for several niche applications including medium- and heavy-duty vehicles, generally as belonging to fleets and/or used in off-road applications, and as a co-fuel for advanced model PHEVs. Many of the newer alternative fuels, like biofuels, present significant technical limitations for heavier duty vehicle end-uses. In contrast, heavier duty vehicles can be more easily adapted to run on natural gas, which already has an established infrastructure and supply stream. As a result, the *State Alternative Fuels Plan* estimates that “natural gas use in heavy-duty vehicles alone could represent about 36 percent of the freight and off-road vehicle fuel use by 2050.” The 2007 IEPR estimates that full implementation of the *State Alternative Fuels Plan* would increase natural gas consumption from its 2006 level of 37.2 million cubic feet (mcf) per day to 87.5 mcf per day in the conservative case, 154.2 mcf in the moderate case, and 239.1 mcf per day in the aggressive case.

Expansion of natural gas use in the transportation sector would benefit from the Energy Commission’s concurrent and coordinated effort to reduce natural gas demand in other sectors. Although natural gas is a small portion (about 1 percent) of California’s current transportation fuel consumption, it is a prominent fuel for electricity generation and for a variety of uses in the residential, commercial and industrial sectors. State policy goals applied to natural gas demand can enable a shift in natural gas demand to the more targeted, harder-to-reach niche applications available within the transportation sector.

Other Emerging Themes and Trends

Looking beyond the upcoming FY, several recently emerged themes in California’s energy sector promise to have a profound effect on the Energy Commission’s current and proposed natural gas research program. The Energy Commission intends to shape and prioritize its long-term research goals to reflect these themes, which include the Zero Energy Homes and Buildings mandate, customer behavior’s impact on energy use, possible expansion of the state RPS into direct natural gas use, and the emergence of a California Smart Grid. In addition, the Energy Commission would develop rigorous approach to evaluate the costs and benefits of its research program to create a feedback loop that would inform future program planning.

Zero Energy Buildings and Communities

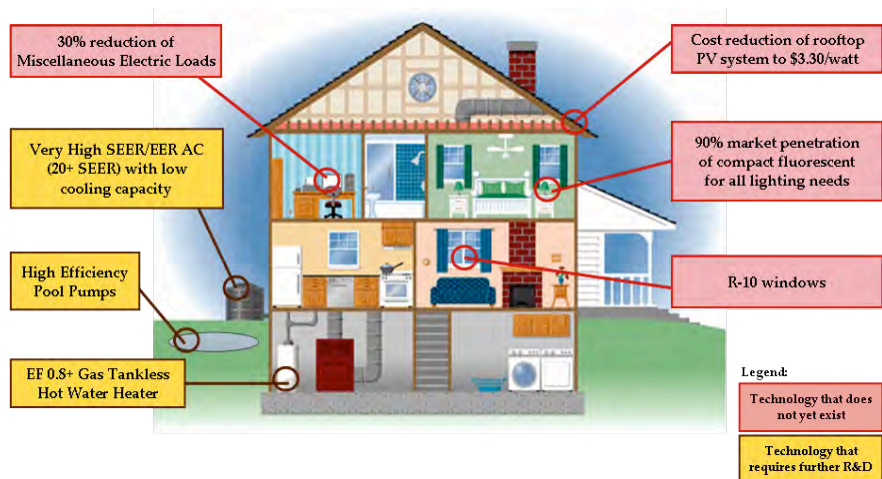
CPUC Decision 07-10-032²⁶ mandates that all new residential construction in California be net zero energy by 2020, and new commercial construction by 2030. In addition, 2008 IEPR Update brings additional policy attention to the goal of net-zero energy communities. Achieving net zero energy in California in a timely manner will require concerted research effort on both the natural gas and the electricity sides of the state’s energy system (Figure 7); natural gas research must enable wide-scale adoption of energy efficiency and renewable thermal energy solutions, while

²⁶ http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/74107.PDF

electricity research will be required to reduce the cost of technology options to improve the viability of net-zero energy buildings and communities. The Energy Commission's natural gas research proposes focusing on technology solutions that would enable the state to successfully meet the zero energy buildings targets.

Research issues pertaining to zero energy buildings and communities would be addressed through projects in Research Area 1 – *Improving Residential, Commercial and Industrial Energy Efficiency*.

Figure 7: RD&D needs for California's zero energy residential homes



California Smart Grid

The Smart Grid is an emerging group of technology solutions to transform the electricity delivery infrastructure that is gaining increasing traction in the energy industry nationwide. California's Smart Grid is envisioned to enable greater integration of renewable generation and other resources at different levels of electricity delivery infrastructure while improving the reliability, resiliency and general functionality of the state's electric grid. As such, the California investor-owned electric utilities agree that the California Smart Grid can provide substantial support to the achievement of California's energy policy target, while end-user representatives view the California Smart Grid as a

promising solution to enable greater penetration of demand response and distributed generation (DG). At a very basic level, natural gas delivery infrastructure is expected to become more intelligent by way of new technologies such as advanced meters (Figure 7). Moreover, natural gas is expected to play a crucial role in the California Smart Grid by fueling large volume of DG and CHP systems and mitigating intermittency of newly implemented renewables. The Energy Commission intends to continue exploring the synergies between direct natural gas use and electricity in designing and operating the California Smart Grid.

Figure 7: Summary of California Advanced Metering Initiative (gas meter data highlighted in orange)

	Pacific Gas & Electric	San Diego Gas & Electric	Southern California Edison
# of Electric Meters	5.1M	1.4M	5.3M
# of Gas Meters	4.2M	0.9M	Gas Utility may connect to AMI
Costs Approved	\$1.7B in July 2006	\$0.6B in April 2007	\$1.7B
Costs Pending Approval	\$0.6B to upgrade	-	-
Deployment Schedule	2006 to 2012	2008 to 2011	2009 to 2012

Research issues pertaining to the nexus of natural gas and the Smart Grid are represented through projects in Research Area 3 – *Improve Natural Gas System and Infrastructure Performance and Reliability*.

Impact of Customer Behavior on Natural Gas Use

Based on its past and recent research efforts, the Energy Commission has noted that the energy consumption behavior of end users plays a crucial part in capturing the benefit of energy efficiency technologies and strategies. Concurrent to its traditional energy efficiency research activities, the Energy Commission would support research activities that shed light on customers' impact on California's overall energy consumption, and optimize the efficiency benefit of efficiency solutions developed through ratepayer-funded energy research.

Research issues pertaining to customer behavior are implemented in projects proposed in Research Area 1 – *Improving Residential, Commercial and Industrial Energy Efficiency* and Research Area 3 – *Improve Natural Gas System and Infrastructure Performance and Reliability*.

Natural Gas Renewable Portfolio Standards

There are active discussions taking place on the possibility of expanding the scope of California's RPS applicable to publicly owned utilities. As California continues to lead other state in its renewable energy mandates, some sort of RPS goals for direct use of natural gas is plausible in the future. The Energy Commission would continue to focus on research projects that facilitate accelerated introduction and adoption of renewable thermal resources to replace conventional natural gas use at the end-use level.

Research issues pertaining to renewable alternative to natural gas would be addressed through projects in Research Area 2 – *Accelerating Adoption of Alternatives to Conventional Natural Gas*.

CHAPTER 4:

Energy Innovations Small Grants Program

Planned FY 2009-2010 EISG Solicitation

Some of the most important discoveries, advances and inventions have emerged from small, innovative sources. The Energy Commission proposes allocating \$1.75 million of its proposed budget for a cross-cutting natural gas research grant program (including administration) to complement ongoing core research for the Energy Commission's natural gas research program. This year's funding for small grants research would be divided into two main parts: transportation-related research (\$0.75 million) and other natural gas research (\$1.00 million).

These solicitations would fall under the existing EISG, a successful program with the objective of providing opportunities for supporting feasibility studies. Since 2006, EISG has included emerging and promising natural gas technologies. The EISG is administered by San Diego State University Research Foundation. Table 7 describes the major activities and preliminary deadlines for this solicitation for research that does not pertain to transportation.

Table 7: EISG FY 2009-2010 Non-Transportation Solicitation Deadlines

Deadline	Date
Pre-proposal Abstracts accepted (optional)	October 1, 2009
Grant Applications Received	November 1, 2009
Energy Commission Approval of Awards	Approx. 20 weeks from cutoff date
Notification of Awards	Within 5 business days (email & web site)
Begin Executing Agreements	April 2010

The Energy Commission proposes that an additional \$750,000 would be allocated for a grant program to solicit specific transportation-related natural gas research. This solicitation would target feasibility research projects with specific focus on transportation-related energy topics. Through EISG, the Energy Commission carries out one solicitation every FY for grant awards for natural gas projects.

These grants would support the Energy Commission's Alternative Fuels research and complement the overarching natural gas research areas by funding projects that aim to reduce the consumption of petroleum-based fuels by promoting and advancing renewable and non-renewable alternative fuels using innovative tools and methods. Research examples include:

- Resources and upstream research for cost effective production technologies for viable transportation fuels.
- Distribution and fuel infrastructure research for cost effective technologies and strategies that solve both technical and social issues related to the introduction of new fuels.
- Transportation small grants would continue to support PIER Vehicle Technologies research by funding projects that reduce vehicle energy consumption through improved vehicle

efficiency, reduced GHG emissions and enhanced viability of alternatively fueled vehicles. Many of these projects would indirectly support natural gas goals regarding fuel efficiency.

Table 8 describes the major activities and preliminary deadlines for this solicitation.

Table 8: EISG FY 2009-2010 Transportation Solicitation Deadlines

Deadline	Date
Pre-proposal Abstracts accepted (optional)	February 1, 2010
Grant Applications Received	March 1, 2010
Energy Commission Approval of Awards	Approx. 20 weeks from cutoff date
Notification of Awards	Within 5 business days (email & web site)
Begin Executing Agreements	August 2010

These projects would benefit ratepayers by reducing natural gas consumption, lowering carbon dioxide and other air pollutants, and lowering natural gas prices. These grants would be designed to assess “proof of concept,” with successful projects considered for substantive research funding in subsequent years. The program has already proven to be a valuable tool for engaging the larger research community, capturing new ideas, and thus ensuring the highest value research is identified and supported by the natural gas program.

Summary of the FY 2008-2009 EISG Solicitation Results

The EISG Natural Gas Solicitation for FY 2008-2009 (#07-01 G) resulted in 17 proposals accepted by the November 30, 2007, deadline. The initial screening, conducted by technical reviewers with recognized expertise in the subject area, resulted in seven eligible proposals to be reviewed by the Program Technical Review Board. After its review, the Program Technical Review Board recommended funding four of the proposals (listed below in Table 9).

The Program and Technical Review Board is comprised of a group of 10 to 14 individuals with recognized energy expertise with representatives from the Energy Commission, California State University, the University of California, private industry, and investor-owned utility companies. The Program and Technical Review Board is responsible for final scoring and preparing a ranking of the grant applications funding for consideration in a public meeting by the Energy Commission. The list of approved projects is presented in Table 9.

Table 9: Approved Grant Proposals FY 07-08 (Cycle 07-01 G Proposals)

Organization	Project Title and Descriptions
Jay Khodadadi, Auburn University	<i>Reducing Natural Gas Consumption by Modifying Containers of Water Heaters</i> Project proposes to prove the feasibility of utilizing a simple ring-like baffle attached to the inside wall of the tank of gas-fired water heaters in order to increase the amount of heat absorbed, thus reducing natural gas consumption.
Randal Perisho	<i>Low Cost Parabolic Trough</i> Project proposes to prove the feasibility of a light weight low cost solar trough that may replace burning of natural gas.
Samy Sadaka, University of Arkansas	<i>Production of Syngas from Dairy Manure to Replace Natural Gas</i> Project proposes to prove the feasibility of using a novel technique to produce high heating value syngas from a dairy manure and wheat straw mixture that may replace the burning of natural gas.
Subramanian Iyer, Energetics, Inc.	<i>Algae Biomass Gasification</i> Project proposes to prove the feasibility of using algae as a renewable biomass feedstock at a cost comparable to current natural gas prices that may replace the burning of natural gas.

CHAPTER 5:

Past and Current Project Highlights

As administrator for the ratepayer-funded natural gas research program for the past four years, the Energy Commission has built a strong foundation to continue to conduct and support research that benefits Californians. Positive feedback loops are generated by the Energy Commission's projects, each successful project continues generating knowledge that improves the state's ability to identify, plan and execute additional natural gas research with compelling benefits.

Many of the natural gas research projects in this program have pronounced relevance to electricity-related technology, policy and infrastructure developments. Such projects encourage knowledge sharing between the natural gas and electricity research efforts. While the natural gas projects are funded separately from the electricity projects, the Energy Commission is in a unique position to leverage experience from the execution and review of outcomes of its electricity research projects to better shape the natural gas projects and vice versa, thus creating a more balanced public interest energy research portfolio.

Improving Residential, Commercial and Industrial Energy Efficiency

Super Efficient Gas Water Heating Appliance Initiative

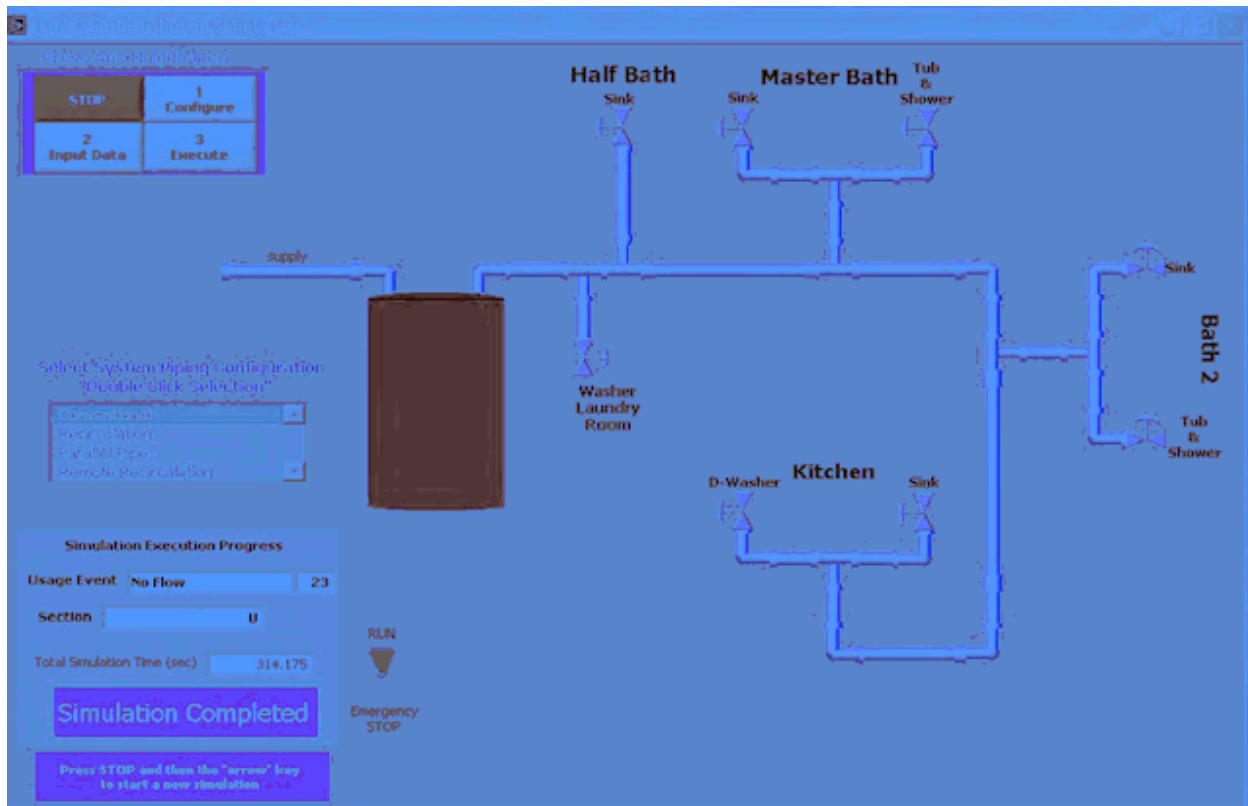
Water heating accounts for 40 percent of the natural gas consumption in the state's building sector, or roughly one-quarter of the statewide natural gas consumption. In 2004, the Energy Commission's Buildings End-Use Energy Efficiency (Buildings) Program funded the Super Efficient Gas Water Heating Appliance Initiative (SEGWHAI) for \$350,000 to identify the processes necessary to fill the market gap between standard efficiency natural gas water heaters and the more efficient, higher-priced units. Valley Energy Efficiency Corporation, successfully developed two-tier, performance-based, energy efficiency criteria for natural gas storage water heaters. The study results are being used by two national organizations, the Consortium of Energy Efficiency and the American Council for an Energy Efficient Economy (ACEEE), to educate the utilities and policy makers of this energy efficiency opportunity. The research study also provides input to federal government programs, such as EnergyStar, to support and develop new nationwide appliance efficiency standards.

Hot Water Distribution System Research

One of the conclusions from the SEGWHAI project is that heat lost through residential and commercial hot water distribution systems represents one of the biggest inefficiencies in California's water heating systems. Various studies suggest that design improvements for the hot water distribution system could increase efficiency by up to 50 percent, while also reducing delivery time. To address fundamental RD&D needs associated with hot water distribution systems, the Energy Commission is funding projects for about \$2.7 million to identify which

aspects of system design, operation and maintenance offer the highest energy savings potential from utility programs or equipment standards. A screenshot of the simulation model user-interface is displayed in Figure 8.

Figure 8: User Interface of HWSim, a hot water distribution simulation model



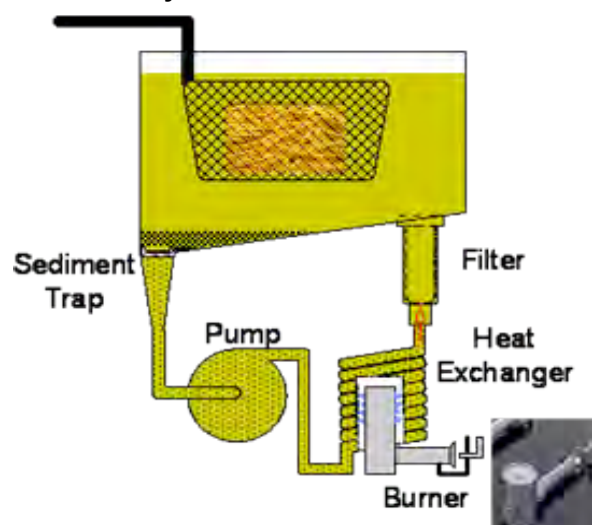
The outcome of this research will assist the American Society of Heating, Refrigerating, and Air-Conditioning Engineers Service Water Heating standards, which are expected to influence hot water distribution system design practices.

This information will also help utilities prioritize and focus their efficiency standards and programs to optimize hot water distribution systems and reduce the demand for natural gas. A more efficient hot water distribution system requires less natural gas to heat water, resulting in savings for ratepayers.

High-Efficiency Low-Oil Volume Fryer

California's commercial cooking industry consumes 200 million therms per year, or roughly 10 percent of the annual natural gas consumption attributed to California's commercial sector. Technology innovation in the commercial food service industry, however,

Figure 8: Schematic Diagram of PITCO "Rocket" Fryer



has centered around productivity improvement, and not on equipment energy efficiency technology. To address this gas saving opportunity, the Energy Commission funded a research project for \$320,000 with the Gas Technology Institute (GTI) to develop a concept prototype of high-efficiency low-oil volume fryer. The result was a prototype that transfers heat more efficiently by incorporating off-the-shelf devices such as oil pumps and heat exchangers. The concept reduces the oil needed for cooking and lengthens its lifetime.

Given the increasing consumer preference toward food prepared with expensive non-trans fat oil, this technology shows promise to achieve significant market penetration in the near future. PITCO, a New England-based manufacturer, is commercializing this technology. If widely adopted, this PITCO “Rocket” fryer could save 40 million therms of gas annually, or 20 percent efficiency savings from the commercial food service industry (Figure 8).

Power Generation Integrated in Burners for Packaged Industrial/Commercial Boilers

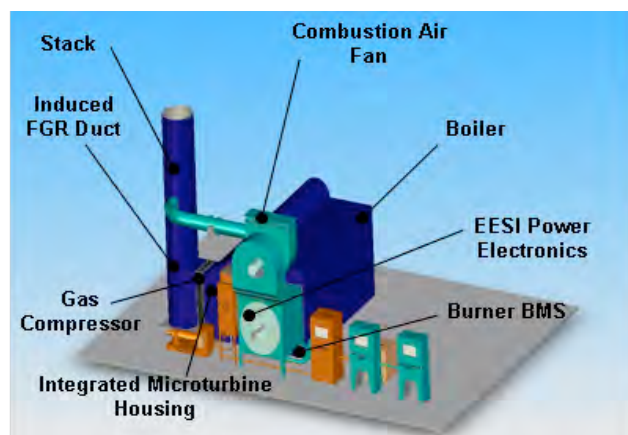
Along with CHP, CCHP systems and natural gas-powered DG systems promise higher energy efficiency and lower carbon emissions at reduced energy costs. To expedite wide-spread adoption of these technologies, the Advanced Generation Program Area funded a demonstration project for a simple cycle micro-turbine generator integrated with a modern low-NOx burner for packaged industrial / commercial boilers (Figure 8).

This project successfully developed and integrated an ultra-clean micro-turbine generator with a boiler for industrial and commercial uses, demonstrating a CHP system efficiency over 80 percent, with an expected payback period of approximately two years. A field demonstration at an industrial facility is currently underway, and an economical CHP package is ready for commercialization.

Demonstration of ThermoSorber Heat Pump Waste Heat Recovery System

California’s residential, commercial, and industrial sector consumes more than 10,000 million therms annually, and produces a considerable amount of waste heat as a byproduct of onsite energy use. The Industrial, Agriculture and Water Program funded Energy Concepts for \$240,000 to demonstrate its ThermoSorber technology, a gas-fired heat pump that supplies air conditioning or refrigeration then uses the waste heat for water heating (Figure 8).

Figure 8: Schematic Diagram of Integrated MTG-Boiler CHP



This technology could capture waste heat in various cooling, hot water, and refrigeration applications in the industrial, commercial, and residential sectors. With a variety of applications and a 28 percent natural gas efficiency improvement potential, this technology has captured the attention of California utilities, including PG&E, which provides rebates for the ThermoSorber.

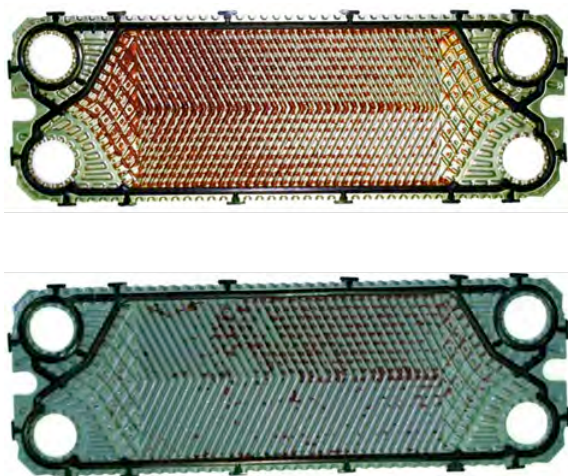
Figure 8: 100-ton ThermoSorber unit installed at a Foster Farm facility in CA



New Coating Material to Reduce Energy Requirement for Industrial Cleaning

Heat exchangers in food processing and dairy facilities that become fouled require frequent cleaning using hot water, which increases natural gas consumption and reduces the overall

Figure 8: Milk processing system component with standard coating (top) and new coating (bottom)



efficiency of the facility. For instance, fouling in milk production facilities require approximately 39 million additional therms of natural gas and 92 million kWh of electricity.

The public interest natural gas program initiated a project for \$210,000 to develop a new non-stick coating material to reduce fouling. The developed product shows promising preliminary results, and will be tested in a demonstration at a California milk processing plant (Figure 8). The expected annual savings for a typical milk plant is 63,000 therms of natural gas and 150 MWh of electricity. Other food processing industries, such as grape juice and orange juice processing facilities, are also expected to benefit from these project results.

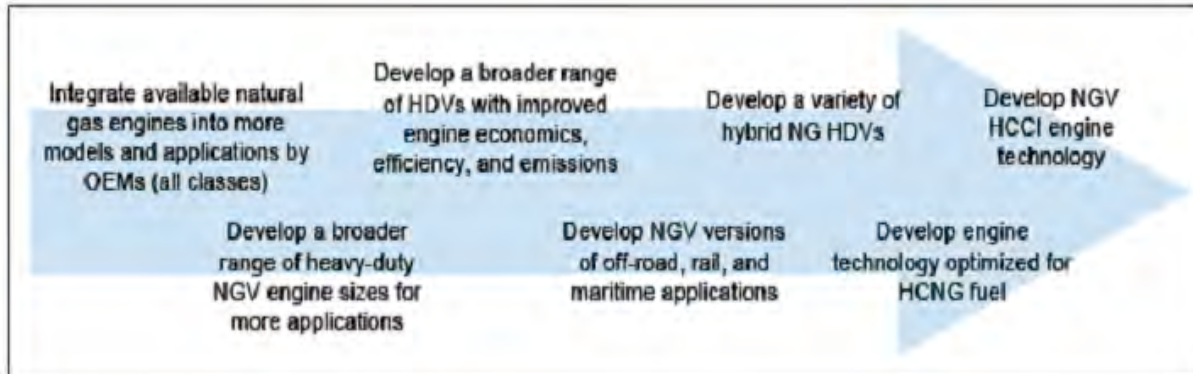
Natural Gas Vehicle Research Roadmap

Given the existing natural gas infrastructure and the lower carbon content of natural gas compared to conventional petroleum-based fuels, natural gas vehicles have the potential to serve as a viable element in the fuel portfolio to meet the state's transportation-related energy targets. Achieving this potential requires concerted actions on the part of vehicle manufacturers, fuel suppliers, researchers, and relevant government agencies, to increase alternative fuel use to consider. To facilitate industry-wide coordination in this area, the Transportation Research Program staff commissioned a Natural Gas Vehicle (NGV) Research Roadmap that develops

the strategic research plan to enhance the viability of natural gas vehicles in California (Figure 9).

The NGV Research Roadmap provides a clear picture of research needs and priorities for successful introduction and adoption of NGV in California. The NGV Research Roadmap also coordinates future research efforts under the common goal of increasing NGV market in California.

Figure 9: Sequence of Priority RD&D Ideas for Natural Gas Vehicle Engine Development and Vehicle Integration



PHEV Research Roadmap

In addition to the NGV Research Roadmap, a PHEV Roadmap is currently in its final stage of development and is being funded through the PIER electricity budget. The PHEV research and the natural gas vehicle research will be integrated to develop optimal transportation solutions for California. For instance, as hybrid vehicles become more widely accepted, integrating natural gas into advanced hybrid vehicle development may occur in all natural gas vehicle markets. Similarly, the gradual emergence and acceptance of fuel-cell vehicles will be accelerated by natural gas vehicles because of the public's growing familiarity with pressurized natural gas fueling as a bridging technology for hydrogen use.

In addition to the NGV Research Roadmap and the PHEV Research Roadmap, the Transportation Program is completing research roadmaps for non-petroleum alternative fuels development and vehicle efficiency technologies. These research roadmaps will complement each other to form a comprehensive transportation research plan that supports the state transportation-related energy policy goals.

Development of High-Pressure Direct Injection Engine for LNG Vehicle Application

The *State Alternative Fuels Plan* notes that "natural gas use in heavy-duty vehicles alone could represent about 36 percent of the freight and off-road vehicle fuel use by 2050." However, one of the findings during the NGV Research Roadmap development was that natural gas vehicle technology integration is a significant hurdle to

Figure 9: HPDI Engine



achieve greater natural gas vehicle market presence, especially for heavy-duty vehicles. Westport was funded \$500,000 to demonstrate its LNG high-pressure direct injection engine in heavy-duty truck applications and has also obtained an additional \$9 million in co-funding for this project (Figure 9). The Transportation Program funds are being used to develop the urea selective catalytic reduction system, which can reduce the engine's emissions levels to a level equal to or lower than 2010 clean diesel standards. These reductions in the trucking industry would have significant implications in California if this technology is adopted statewide.

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

Parabolic Trough Solar Collectors for Industrial Application

Although a proven technology, solar thermal heating has yet to fully penetrate the industrial market due to the intermittent nature of solar resources. The Energy Commission funded a demonstration of a parabolic trough solar system to deliver process heat to the Frito-Lay plant located in Modesto, California (Figure 9). Before this project, high-temperature solar thermal technology was not integrated into an industrial operation. This project successfully demonstrated that existing solar thermal technology can supply sufficient energy to power critical industrial processes while meeting the strict reliability and precision standards required for industrial applications.²⁷ The solar technology project provides a novel method of reducing natural gas consumption for many other industrial facilities in California using resources that are abundantly available.

Figure 9: Promotional Flyer of Frito-Lay Solar Thermal System



Solar Combined Heat and Power System Demonstration

An emerging solar CHP technology that demonstrates the benefits of substituting solar energy for natural gas was field-tested at two research facilities and the San Diego State University campus (Figure 9). The technology, developed by EDTEK, uses a solar dish system to convert solar radiation into heat and electricity a cost of \$0.04/kWh²⁸, a significant improvement compared \$0.25 - \$0.40/kWh associated with traditional solar solutions. It also compares favorably with grid energy, which averages \$0.10/kWh in California. Currently, two units have been installed at the demonstration site, producing efficiencies of 25.7 percent electrical and 74 percent thermal. Extensive system testing is underway to guide design improvement for 13 other units that will be installed at a later date.

²⁷ The system produces 14,700 MMBTU a year, roughly the same amount of energy to run the SunChips manufacturing line, which operates at about 14,600 MMBTU a year (2.4 MMBTU/hour).

²⁸ When simultaneously generation both electric and thermal energy.

Figure 9: EDTEK SolBlu™ Solar CHP System



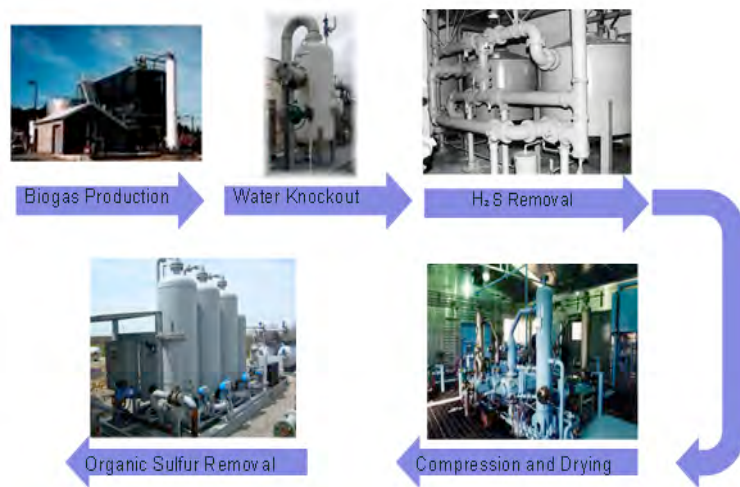
EDTEK has since received additional venture capital funding to continue their research effort on their solar CHP system toward successful market adoption of the technology. Wide-scale adoption of this technology will directly displace California's conventional natural gas consumption.

Production and Conditioning of High Sulfur Biogas for Fuel Cell CHP Generation

The Energy Commission also funded a project using California's renewable biomass resources; converting wastes from an onion processing plant into gaseous fuel that can be used for producing heat and electricity. Figure 9 illustrates the process involved.

The demonstration at a Gills Onions facility in Oxnard, (which is responsible for 10 percent of California's onion production) will improve energy efficiency, reduce operating costs of biogas production and conditioning process, reduce GHG emissions, and serve as a model for other food processing operations in California to convert waste into fuel. Sempra Energy is also interested and provided a letter of support with the proposal and is considering participating in the project.

Figure 9: High-Sulfur Biogas Production and Conditioning Process



Purification and Liquification of Biomethane Landfill Gas for Transportation Fuel

California faces a growing need for non-petroleum based alternative fuels in the transportation sector. To increase the diversity of California's transportation fuels an LNG project will demonstrate liquification technology used to recover and convert renewable landfill biomethane to liquefied natural gas. This project directly addresses the technical and economic challenges associated with converting landfill gas to LNG allowing renewable LNG to be used as a transportation fuel. Successful completion of this project will prove the technical feasibility of using landfill gas and other renewable methane as a viable substitute fuel.

Dairy Biogas Production and Conditioning Technologies

Biomethane produced at dairy farms has the potential to serve as a renewable resource for transportation and electricity generation sectors in California. To assess the magnitude of this potential, the Energy Commission is funding a research project that identifies research needs for biogas conditioning technologies to enable the use of dairy biogas for different applications. The project will quantify the technical and environmental performance of California's dairy biogas power systems, including manure and effluent handling, anaerobic digestion and biogas-to-electricity generation processes.

Improve Natural Gas System and Infrastructure Performance and Reliability

Growing demand for natural gas and an aging infrastructure in California poses significant challenges for the state's natural gas ratepayers and stakeholders. Lack of stakeholder collaboration and regulatory constraints to develop new infrastructure are some of the other main factors contributing to the reduced gas delivery capacity and rising energy costs. The safety and security of the state's gas infrastructure are important priorities for California. In particular, the procurement of sufficient natural gas supplies and storage capacity will continue to be an issue for California in the coming years. However, there has been little development of tools or methods to evaluate public benefit of natural gas infrastructure enhancement and associated impacts on gas markets, and analysis of different regulatory frameworks. The Energy Systems Integration Program is addressing these critical issues that do not directly fall under energy efficiency or renewable energy categories, but nonetheless provide significant long-term benefit to California ratepayers.

Market and Regulatory Options Research for California Natural Gas Storage

Enhanced natural gas storage in California provides two major benefits to California gas ratepayers: reliability and cost stability. First, storage enhances gas service reliability by helping utilities meet peak gas demand. Second, storage moderates seasonal price fluctuations and prevents extreme hike in natural gas prices by enabling utilities and other gas users to purchase extra natural gas when prices are lower. To further optimize the California natural gas system to meet changing demand and regulatory requirements, the Energy Commission funded two projects as part of a research opportunity notice.

In one project, the Energy Commission funded MRW Associates to assess regulatory market and physical barriers for expansion of gas storage infrastructure in California. This study examined whether factors such as regulatory requirements, incumbent advantages and geophysical conditions are inhibiting the expansion of gas storage infrastructure in California. In another project, the Energy Commission funded Black & Veatch to assess whether underground storage will play a significant role in meeting natural gas requirements. This study estimated how the natural gas market in California will evolve through 2020 under various regulatory and market scenarios, and analyzed the role of storage and the viability of storage development in California.

These projects provide projected gas prices, demand, supply and market volatility in addition to the value and barriers associated with gas storage in California (Table 10). The results of these projects will guide California and the stakeholders of the state's natural gas system in effective improvement of the infrastructure that would minimize future market disruption and price volatility. They will also provide a framework for future assessments of market reactions to infrastructure and regulatory changes.

Table 10: Potential Barriers to Natural Gas Storage Development

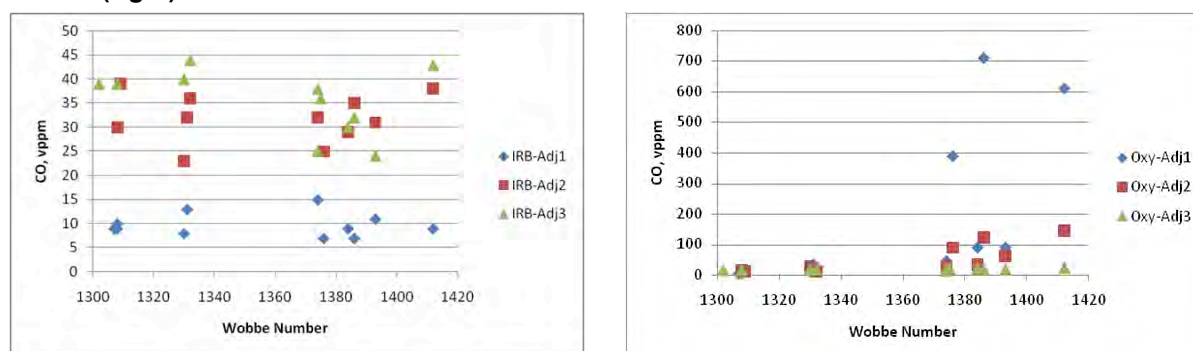
Barrier Type	Description of Potential Barrier
Regulatory	Costly proceedings; may be cheaper for incumbent than entrant, especially in the case of an expansion.
	Utilities able to exercise eminent domain, even when only part of the project is for core customers.
	Price cap set by CPUC effectively a cap for potential entrants into a competitive market.
Incumbent Advantages	Difficult for entrants to achieve the economies of scale possible for incumbents.
	Cheaper for incumbent to expand current facility than to build new facility.
Market	Large capital, regulatory, permitting and marketing costs may make only large projects viable. This may decrease prices and inhibit cost recovery potential of new entrants.
	Entrants would require land and access to distribution owned by incumbent utilities.
Physical	Storage facilities require specific geology and land conditions. Economically viable sites may have already been developed.

Reducing the Environmental Footprint of California's Natural Gas System

LNG Interchangeability Assessment

The Energy-Related Environmental Research Program is addressing the need for greater fuel diversity through its environmental and device performance project. This project will identify and evaluate safety and emissions performance of LNG and other natural gas fuel substitutes for use in various industrial, commercial, and residential burners (Figure 10).

Figure 10: CO levels for varying fuel compositions for radiant burner (left) and oxygen-gas burner (right)



This research will also evaluate the emissions of the fuel substitutes in order to determine how to safely integrate the fuel substitutes with existing burner technology. The project results provide information to the state's policymakers of potential concerns regarding the introduction of LNG into California's gas supplies and environmental, health and safety issues associated with LNG use. The knowledge research will also inform government agencies such as the California Environmental Protection Agency and regional air quality management districts of potential regulatory obstacles associated with the use of substitute gases in various applications.

California Automated Unmanned Aerial Vehicle Air Pollution Profiling Study

Black carbon particulates are not formally considered GHG, but new research has shown that black carbon contributes to climate change. Black carbon deposited over snow accelerates the melting of the snow-pack due to an increase in solar absorption, although the magnitude of this effect in the Sierra Nevada is not known at this time.

To start assessing the impact of black carbon to California's climate and snowpack, the Energy Commission is funding a research project to measure black carbon aloft for a period of one year. Sporadic prior measurements suggest that a substantial fraction of black carbon over California skies might originate from Asia but it is not known if this is the case during other times of the year. Lightweight Autonomous Unmanned Aerial Vehicles are measuring ambient concentration of black carbon and solar radiation. The research will be completed in December of 2009. Scientists will use the collected data to estimate the climatic effects and the potential source origin for the measured black carbon aloft.

Observation of Non-Carbon Dioxide GHG Emissions from California

Improving the accuracy of in-state GHG emission inventories is a critical step in demonstrating compliance with California's GHG emissions targets. One of the first regional GHG monitoring studies in the United States is being funded and will measure atmospheric concentrations of non-CO₂ GHG including methane, or natural gas, to verify the accuracy of estimated GHG emissions from in-state sources. Two communication towers that monitor atmospheric concentration of GHGs in California have already been constructed. Phase I of this project

completed by March 2009 will establish a baseline, since non-CO₂ GHGs such as methane account for more than 15 percent of total GHG emissions in California. This data is vital in tracking California's performance in meeting its emission targets established by policies such as AB 32.

Appendices

Appendix I. PIER NG Program History and Regulatory Background

Program History

In 2004, the California Public Utilities Commission (CPUC) approved the collection of a ratepayer-funded natural gas surcharge for energy research, and assigned the California Energy Commission (Energy Commission) to administer that research (Decision 04-08-010¹). Decision 04-08-010 required delivery of a report with “...information on costs, balances of approved project budgets and expenses, benefits, and progress of R&D [research and development] projects.” Under that decision, these reports are to be filed annually by March 31 with the Energy Division. Subsequent legislation including Senate Bill (SB) 1250¹⁴ and SB 76⁵ changed several administrative aspects and added new responsibilities for Energy Commission research using the natural gas funds. CPUC Resolution G-3394²⁹, passed in December 2006, changed the reporting period to a fiscal year basis and the due date for the annual plan from March 31 to October 31.

CPUC Decision 04-08-010

In Decision 04-08-010, the CPUC approved the Energy Commission as the administrator of natural gas research and development. The CPUC Decision creating the natural gas research fund was approved in August, and two and a half months later the 2005 Program Plan was due to the CPUC on October 31, 2004. The 2005 Program Plan and Budget was subsequently approved at the December 16, 2004, CPUC Business Meeting.

Senate Bill 1250

SB 1250 (Chapter 512, Statutes of 2006) changed the natural gas research fund requirements as follows:

Section 895 of the Public Utilities Code is amended to read: Notwithstanding Section 13340 of the Government Code, moneys in the Gas Consumption Surcharge Fund are continuously appropriated, without regard to fiscal years, as follows:

- a. To the commission or an entity designated by the commission to fund programs described in subdivision (a) of Section 890. If the commission [CPUC] designates the State Energy Resources Conservation and Development Commission to receive funds for public interest research and development, both of the following shall apply:
 1. The Controller shall transfer funds to a separate sub account within the Public Interest Research, Development, and Demonstration Fund to pay the State Energy Resources Conservation and Development Commission for its costs in carrying out its duties and responsibilities under this article.
 2. The State Energy Resources Conservation and Development Commission may administer the program pursuant to Chapter 7.1 (commencing with Section 25620) of Division 15 of the Public Resources Code.

²⁹ http://docs.cpuc.ca.gov/PUBLISHED/FINAL_RESOLUTION/63130.htm

This amendment changed how the natural gas research funds are encumbered and managed. Under the previous statutes, natural gas funds were continuously appropriated to, and retained by, the CPUC. When the Energy Commission, acting as administrator, encumbered the funds, those funds were drawn directly from the CPUC's account. SB 1250 made a significant change to streamline this process. While the funds remain continuously appropriated to the CPUC, any funds that the CPUC authorizes the Energy Commission to manage are now transferred to a sub-account in the PIER fund. The Energy Commission cannot encumber funds until they are appropriated in the Legislature's annual budget. For example, the 2007 natural gas research funds available on January 1, 2007, could not be drawn upon until the Energy Commission received the spending authority in the FY 07-08 Budget Act which passed in August 2007.

Senate Bill 76

Transportation Research

SB 76 (Chapter 15, Statutes of 2005) added new responsibilities to the administration of the natural gas research. SB 76 requires the Energy Commission and the California Air Resources Board (ARB) to jointly develop a strategic research plan. Also, SB 76 allows that up to one-third of the funds may be used for "transportation related public interest energy research and development provided the research provides natural gas ratepayer benefits." SB 76 became effective January 1, 2006.

Co-planning with the California Air Resources Board

Senate Bill 76 requires that the Commission execute its research expenditures pursuant to a "strategic research plan jointly developed by the state Air Resources Board and the Energy Resources Conservation and Development Commission to ensure coordination of the state's energy and environmental research priorities." The Energy Commission and the ARB agreed to use the Investment Plan as the basis for joint planning. Additionally, Commissioner James Boyd serves on the Energy Commission's Research, Development & Demonstration Committee and chairs the multi-agency Climate Action Team Research Subgroup, thereby providing another channel for coordination and co-planning.

Appendix II. Reduction in Program Administration Costs

In the *Natural Gas Research, Development and Demonstrations Program Plan for FY 2008-2009*, submitted in April 2008, the Energy Commission requested \$3.1 million, or 15% of the total natural gas annual program funding, to cover the program administration expenses. This was an increase in the program administration budget from 10% to 15% when compared with the FY 2007-2008 budget. There were two reasons for this increase. First, three new permanent staff positions were approved for FY 2007-2008 to help implement the natural gas RD&D program. Second, the natural gas staff was provided more access to the competitively selected Program Technical Support Contracts used to assist with expertise that does not reside on the Energy Commission staff and obtain assistance with road mapping, program planning and other areas where special expertise is needed for short term projects.

In response to questions from the CPUC staff on FY 2008-2009 program administration costs, Energy Commission staff completed a review of the actual expenditure to date in FY 2008-2009 to determine if the budgeted 15% program administration costs were in line with actual expenses. After reviewing the expenses, it was determined that administrative costs were lower than expected and approximately \$700,000 in FY 2008-2009 Program Administration funds would be better spent on natural gas systems integration research efforts. Therefore, the Energy Commission is requesting approval to transfer \$700,000 in FY 2008-2009 Program Administration funds to research projects.

Table 11: Requested Reduction in Program Administration Expenses for FY 2008-2009

Expense Category	Funds Allocated
Approved Program Administration Budget FY 2008-2009	\$3,100,000
Proposed Reduced Program Administration Budget FY 2008-2009	\$2,400,000
Difference (to be transferred from Program Administration to Research upon CPUC approval of FY 2009/2010 Budget Plan)	\$700,000

This reduction in program administration funding results in a lowering of the percentage needed for Program Administration for FY 2008-2009 from 15% to 11%. Based on this analysis, the proposed FY 2009-2010 budget for program administration funding is 11% including personnel costs and technical assistance.

Appendix III. Summary of PIER NG Research Projects

Table 12: PIER NG Research Projects Funded in FY 2005

Title	Company	Research Description	Funding
Develop Recommendations to Improve Hot Water Equipment and System Efficiencies in California Homes	Lawrence Berkeley National Laboratory	This project will include several research tasks with the purpose of increasing the energy and water efficiency of residential water heaters and hot water distribution systems (HWDS). The first tasks focus on providing HWDS data, analyses, and recommendations to the 2008 Title 24 Residential Building Energy Efficiency Standards proceeding. The second set of tasks consists of three pilot phase or feasibility studies that will be used to plan future research projects to assess residential hot water usage patterns, and to improve the efficiency of water heating technologies and distribution systems.	\$1,396,000
Super Efficient Gas Water Heating Appliance Initiative	Valley Energy Efficiency Corporation	This effort will fund the first phase of the Super Efficient Gas Water Heater Appliance Initiative (SEGWHAI), to develop the foundation for this multi-year initiative. This work will include the technical and market analyses necessary to determine the best ways to facilitate achieving a 30 % efficiency improvement in gas water heaters. At the end of this first year, this initiative should be at the beginning of the prototype development stage.	\$395,303
Commercial Gas Fryer for Food Service	Gas Technology Institute	This purpose of this project is to design, develop and test a commercially viable gas fryer that reduces energy costs, improves performance, and reduces oil consumption. The contractor will develop specifications and fryer designs concepts; fabricate, assemble, and bench test the fryer; and then conduct computational fluid dynamics tests to analyze both heat transfer and combustion. A prototype fryer will be built and tested according to ANSI and ASTM standards. The contractor will also develop a California market transformation plan outlining activities that Pitco, the key partner, can use to introduce the new gas fryer product.	\$357,802
Next Generation Instantaneous Water Heater	Gas Technology Institute	The contractor will provide a review of available information on current instantaneous water heaters and conduct stakeholder interviews to identify technical and market barriers affecting the adoption of the technology in California. Current instantaneous water heater technology will be evaluated for its market potential and energy savings potential. The contractor will recommend next-generation instantaneous water heater technology that can be successful in the California market.	\$200,738
Improved Natural-Gas Fired Aluminum Smelter Burner	Gas Technology Institute	GTI proposes to install a demonstration of a commercial size prototype flex-flame burner in California. Thorock Metals in Compton, California hosted the early demonstration tests. Field demonstration is slated to be conducted over two years and will consist of parametric and life-cycle tests to optimize operating conditions, to confirm burner reliability, and to collect data on decreased emissions and energy use. The burner design is expected to lend itself to mass production.	\$359,990
Design & Development of a Very High Efficiency / Low-Emissions Natural Gas-Fired Boiler	Gas Technology Institute	GTI proposes to install a demonstration 10 to 15 million Btu/h Super Boiler in California. Field demonstration will consist of parametric and life-cycle tests of up to 12 months. At the conclusion of the demonstration period, the host site will have the option to purchase the Super Boiler for continued operation at its facility. The design is to meet the criteria of being mass producible.	\$239,969
Design & Development of Low-Cost High-Temperature Solar Collectors for Mass Production.	UC Merced	The purpose of this PIER contract is to demonstrate cost-effective high-temperature solar collectors for the production of heat for industrial processes and absorption chillers for refrigeration . The design is expected to meet the criteria of having an installed cost of no more than \$15/square foot of reflector area in 2005 dollars. These results will be in line with the criteria identified by the CPUC (D.04-08-010) for public interest gas RD&D projects: Focus on energy efficiency, renewable technologies, conservation and environmental issues.	\$577,563
Reduce Natural Gas Use for Industrial Process Heat using High-Temperature Parabolic Trough Solar Collectors	American Energy Assets	Industrial Solar Technology Corporation (IST) will install a parabolic trough solar system to deliver process heat to the Frito-Lay plant located in Modesto, California. The proposed solar heating system totals 54,500 sq. ft. of net collector aperture area. It is estimated that the system will deliver 14 billion Btu/year of thermal energy, which will displace about 19 billion Btu/year of natural gas currently used to heat water and generate	\$700,000

Reduce Natural Gas Use for Industrial Process Heat using High-Temperature Parabolic Trough Solar Collectors	American Energy Assets	Industrial Solar Technology Corporation (IST) will install a parabolic trough solar system to deliver process heat to the Frito-Lay plant located in Modesto, California. The proposed solar heating system totals 54,500 sq. ft. of net collector aperture area. It is estimated that the system will deliver 14 billion Btu/year of thermal energy, which will displace about 19 billion Btu/year of natural gas currently used to heat water and generate steam.	\$700,000
Natural Gas Variability in California: Environmental Impacts and Device Performance	Gas Technology Institute	The purpose of this project is to test, evaluate, and model classes of industrial, commercial, and residential burners and their combustion control systems to determine performance and emissions effects of liquefied natural gas (LNG) and other substitute gases relative to traditional natural gas. This interchangeability information will provide a means to operate a flexible, safe natural gas system using the widest gas supply options for California customers.	\$3,000,000
Improved Greenhouse Gases Inventory Methods for California Landfills	Landfills +, Inc.	This project is generating the information and developing the model that will be used to improve California's inventory of methane emissions from landfills. The improved inventory methods will enable other agencies to encourage and track methane reductions. The Climate Action Team has identified controlling emissions from landfills as a near-term option for the California Integrated Waste Management Board, to help meet the State's greenhouse gas emission targets. Improved inventory methods will also address the needs of the California Air Resources Board in relation to AB 32. The research will rely on data currently collected and compiled, as well as on limited site-specific field data. The Integrated Waste Management Board and local regulatory agencies are key partners in this research.	\$399,929
Climate Change and Sea Level Rise: Implications for the California Coast	University of Florida	The purpose of this project is to: (1) collect geological and geomorphological data to better understand shoreline change during recent times; (2) collect information regarding the transport of sediments from river systems to coastal regions (mostly through a critical review of the existing literature); (3) enhance the coastal evolution model developed in collaboration with the Kavli Institute and Scripps Institution of Oceanography and the University of Florida; (4) use the new model to identify hotspots of potential erosion or accretion along the California coast; and (5) use different sea level rise scenarios to estimate potential shoreline changes in important California coastal areas.	\$599,625
Energy Efficient Natural Gas Chillers, Water Heating and Food Service Equipment	Pacific Gas and Electric Company	The proposed research will create a roadmap for advancing technology in the gas-fired commercial water heating systems and gas fired commercial food service areas within the food service industry. The research will also provide the basis for developing and advancing the focus on natural gas cooling as well as proving opportunities for future research in this area.	\$667,000
Super Boiler	Gas Technology Institute	The purpose of this project is to develop a first-generation Super Boiler and demonstrate it at an industrial site in Southern California. The Super Boiler technology developed by GTI and Cleaver-Brooks uses a combination of advanced staged combustion with interstage cooling and advanced membrane technology that recovers flue gas moisture and its latent heat. Lab tests with a 75-horsepower boiler have shown the technology capable of fuel-to-steam efficiency exceeding 94 % together with NOx emissions below 5 ppmv. The boiler is also more compact than conventional models and reduces water consumption by up to 5 %, making it attractive to potential end-users. In the current phase of the project, a 300-horsepower Super Boiler will be designed, built, installed, and demonstrated at a manufacturing facility in Southern California.	\$397,563
Ultra Low Nox Burners	Gas Technology Institute	The purpose of this project is to develop and demonstrate a 5-ppmv ultra-low-NOx burner for industrial water tube boilers that is based on GTI's patented Forced Internal Recirculation technology. GTI has teamed up with Coen Company of Burlingame to develop this burner and demonstrate it at a site in Pasadena (California Institute of Technology). The FIR burner is capable of reaching this level of NOx emissions with reduced flue gas recirculation and lower excess air than other types of ultra-low-NOx burners. In this project, the burner has been developed and a 62-million-Btu/h prototype will be demonstrated on a water tube boiler at the Pasadena site.	\$43,638
Power Generation Integrated	CMC-Engineering	This purpose of this project is to develop, demonstrate and introduce a novel, complete, packaged combined	\$223,443

Fuel Cell Demo	Logan Energy, Inc.	The purpose of this project is to maintain two (2) PEM fuel cells that are to be installed in San Diego, one as a component of a "sustainable communities" project and the second at a City of San Diego office complex. This work will help to bring the benefits of distributed generation technologies, particularly fuel cells, to the California consumer. The contractor is to install the unit, start -up and commission the fuel cell, furnish as-built plans, and provide one-year maintenance, service, and customer support.	\$50,000
Pipeline Integrity Management for Ground Movement Hazards	Pipeline Research Council International	The purpose of this project is to develop an improved, comprehensive set of guidelines and recommended practices that can be implemented within the industry for evaluating pipelines in areas subjected to large-scale ground movements. The project consists of five major activities: (1) defining geohazards; (2) improving methods to model pipeline-soil interaction; (3) improving models of pipeline response to geohazards; (4) developing improved methods to mitigate pipeline risk posed by geohazards; and (5) compiling a guidance document available to the pipeline industry, public agencies, and engineering consultants as a free download from the PRCI web site. PRCI will support regular updates to the guidance document. The project will last 30 months. The U.S. Dept. of Transportation and other parties will provide \$815,033 in match funding.	\$140,000
Production and Conditioning of High Sulfur Biogas for Fuel Cell Combined Heat and Power Generation	Gas Technology Institute	In the context of a commercial application of food waste bio-power, the Gas Technology Institute will demonstrate high-sulfur biogas cleaning and conditioning to stringent fuel cell gas quality levels.	\$394,119
Biogas-Powered 100kW Microturbine with Ultra-low Emissions for CHP Applications	Lawrence Berkeley National Laboratory	Lawrence Berkeley National Laboratory will demonstrate a recuperated microturbine with a low swirl ultra-low emission combustor designed for operation on biogas and capable of meeting the California Air Resources Board (CARB) 2007 distributed generation emission standards for fossil fuels (which is same as CARB proposed 2013 Waste Gas Emission Standards). The proposed unit will operate as a combined heat and power (CHP) system. It will replace natural gas by using digester gas produced at a waste water treatment facility. The waste heat from the microturbine will be used at the facility.	\$357,065
Hot Water Data Analysis and Field Test	Lawrence Berkeley National Laboratory	Collect and assess field data for hot water systems energy uses.	\$50,400
2005 Plan CA Natural Gas Price Shock Survey	Toulan School of Urban Studies and Planning, Portland State University	Developing improved knowledge of consumer response to the large natural gas price increases expected during the winter of 2005-2006. The data collected at this time can later be analyzed to better inform longer-term consumer focused policies, programs and utility rates. The research shall: (1) develop a research design, (2) construct a survey instrument, (3) develop a representative random sample of California residential households, (4) use telephone interviews to administer the survey, (5) and combine survey data with information from utility bills and weather observations.	\$324,800
San Jose State University Foundation Environmental Business Cluster	San Jose State University Foundation	Provide PIER funded contractors commercialize their technologies through market assessment, business plan development and links to financial community.	\$77,986
Requirements Engineering Services for the PIER Buildings Program Area	L Monte Information Services	Provide assessment of the value of using requirements engineering in the assessment and implementation of new and emerging energy efficiency and demand response technologies sin commercial buildings	\$47,090
San Jose State University Foundation Environmental Business Cluster (EBC)	San Jose State University Foundation	Provide additional support to the PIER funded contractors commercialize their technologies through market assessment, business plan development and links to financial community.	\$28,334
		Total	\$11,028,357

Table 13: PIER NG Research Projects Funded in FY 2006

Title	Company	Research Description	Funding
Gas Storage Technology Consortium Membership for 3 calendar years (2006-2008)	Gas Storage Technology Consortium	Join the Gas Storage Technology Consortium (GSTC) as full members for a cost of \$2,500 for three calendar years (2006, 2007, and 2008). The GSTC was established in June 2004 with a five-year contract from the U.S. Department of Energy National Energy Technology Laboratory. Since then the GSTC has co-funded 12 projects totaling \$1.69M. Currently there are 44 members in 18 states plus 1 in D.C. and 1 in Canada. The mission of the GSTC is to assist in the development, demonstration and commercialization of technologies to improve the integrity, flexibility, deliverability, and cost-effectiveness of the nation's underground natural gas/hydrocarbon storage facilities.	\$2,500
Power Generation Integrated in Burners for Packaged Industrial/Commercial Boilers	CMC-Engineering	The purpose of this project is to develop, demonstrate and introduce a packaged CHP system that integrates an unrecuperated 80 kW microturbine with a ultra low NOx burner for packaged boilers. All of the waste exhaust heat of the microturbine is recovered within the boiler inlet air, thereby eliminating the need for waste heat recovery in a recuperator, a heat exchanger that is an expensive component of a conventional microturbine generator.	\$168,718
Hybrid Optimized Tankless Water Heater	Gas Technology Institute	This project will explore the possibility of a hybrid water heater which combines some of the features of a tankless with a storage water heater. This unit would essentially consist of a small, highly insulated tank with the largest burner which can be accommodated with a 0.5 inch gas line. The project will explore the need for controls, the performance impacts of different size storage tanks and burners, and the practicalities of cost of manufacture and installation of such a unit.	\$446,494
Improved Natural-Gas Fired Aluminum Smelter Burner	Gas Technology Institute	GTI proposes to install a demonstration of a commercial size prototype flex-flame burner in California. Thorock Metals in Compton, California hosted the early demonstration tests. Field demonstration is slated to be conducted over two years and will consist of parametric and life-cycle tests to optimize operating conditions, to confirm burner reliability, and to collect data on decreased emissions and energy use. The burner design is expected to lend itself to mass production.	\$14,573
Natural Gas Variability in California: Environmental Impacts and Device Performance	Gas Technology Institute	The purpose of this project is to test, evaluate, and model classes of industrial, commercial, and residential burners and their combustion control systems to determine performance and emissions effects of liquefied natural gas (LNG) and other substitute gases relative to traditional natural gas. This interchangeability information will provide a means to operate a flexible, safe natural gas system using the widest gas supply options for California customers.	\$736,690
Solar Combined Heat and power System	EDTEK	This project is the next phase of a previous PIER funded project, which was performed between 1999 and 2002. EDTEK has developed a low-cost, co-generating solar concentrator system that efficiently produces hot water and electricity. The solar combined Heat and Power system will be field demonstrated to confirm the long-term operational viability. Under this proposed project, the Contractor will be teamed with the California State University San Diego to address the field-testing issues by installing a 48 kw thermal/15 kw electrical system (fifteen 2-axis tracking parabolic 4-dish cogeneration systems) on the university campus and monitoring operation for a one-year period.	\$500,000
Estimation of Long-Term Energy-Efficiency Potentials for California Buildings and Industry	Lawrence Berkeley National Laboratory	Under this project the researchers are developing long-term energy efficiency supply curves (i.e., graphic displays of costs and availability of resources) under different socioeconomic scenarios. They are using the results of the investor-owned utilities study as a starting point and will extend this study to 2050.	\$550,000
Observation of Methane and other Non-Carbon Dioxide Greenhouse Gas Emissions from California	Lawrence Berkeley National Laboratory	Researchers will measure atmospheric concentrations of CH ₄ and other non-CO ₂ greenhouse gases and study the use of the data collected to verify the accuracy of estimated GHG emissions from in-state sources and determine if ambient measurements could be used to track in-state emissions. This will be the first time that researchers will investigate the feasibility of using ambient GHG measurements to track emissions at the regional or state level.	\$660,000

Reverse Annulus Single Ended Radiant Tube (RASERT)	Gas Technology Institute	The purpose of this PIER contract is to demonstrate a cost-effective Gas Fired Reverse Annulus Single Ended Radiant Tube (RASERT) that combines high energy efficiency (68 %) with lower Nitrous Oxide emissions (50 % reduction). This demonstration is intended to validate the technology performance, quantify efficiency improvements, and engage industry partners and utilities in advancing the technology via follow on commercialization actions. Testing will be performed at a California host site. These results will be in line with the criteria identified by the CPUC (D.04-08-010) for public interest gas RD&D projects: Focus on energy efficiency, renewable technologies, conservation and environmental issues.	\$284,969
High Efficiency Gas-Fired Drum Dryer for Food Applications	Gas Technology Institute	The purpose of this PIER contract is to demonstrate a cost-effective Gas Fired Drum Dryer that combines high energy efficiency (75-85 %) with lower Nitrous Oxide emissions (<50 parts per million). Testing will be performed at a California host site.	\$950,458
Validation of a New Technology for Real-Time Measurement of the Isotopic Composition of Methane in Ambient Air	Gas Technology Institute	Researchers will field test and verify a new instrument (the GyroTM) capable of measuring the isotopic composition and atmospheric concentration of both methane and CO2 in real-time. Methane is a potent greenhouse gas -- 21 times the global warming potential of carbon dioxide and California is concerned about fugitive methane emissions throughout the state. Use of this instrument could vastly improve inverse methods measurements, with the potential to significantly improve California's methane and CO2 greenhouse gas inventories.	\$250,000
Hot Water Distribution System Research	Heschong Mahone Group	This will be an integrated program of research that analyzes how HWDS function in the field, and what factors lead to successful outcomes. It will identify what aspects of system design, operation and maintenance offer the greatest opportunities for energy savings from utility programs and changes to water and energy efficiency standards, and which of these opportunities can most readily be achieved given cost constraints, typical design practice, available technologies and cultural factors. Many energy saving opportunities will be identified and quantified, and market change will be achieved by: Providing evidence of achievable savings to building owners and designers. Providing design advice to make the design process easier and cheaper. Working with product manufacturers to improve performance and/or reliability. Informing the development of codes and standards, and of utility programs.	\$500,000
Water Heating and Hot Water Usage in California Homes	Lawrence Berkeley National Laboratory	The proposed research will continue efforts to characterize residential hot water usage through a partnership with the Department of Water Resources (DWR). This project will measure how much water and energy is wasted in hot water distribution systems (HWDS) in California residences and investigate the effectiveness of current retrofit options in reducing this waste of water and energy. This research will also continue supporting the market introduction of efficient gas storage water heaters by providing evaluations of promising technology innovations. This project will conduct efficiency tests on three promising, alternative storage-type gas water heaters. The proposed research also includes the continuation of efforts to collect the necessary data, conduct analysis and develop recommendations for energy-related code changes to improve the efficiency of HWDS.	\$553,500
PIER-NG Transportation Research 2006 Program, California Air Resources Board Projects	California Air Resources Board	The objective of these tasks are to: (2) validate the performance, reliability, durability and operating costs so that commercial applications of the engine can occur within the 2007-2010 timeframe, (3) characterize the significance of lube oil in PM formation and determine if it can be formulated to reduce in-use PM emissions, (4) determine the physicochemical and toxicological properties of the semi-volatile and non-volatile fractions of PM from heavy- and light-duty vehicles operating with and without emissions control technologies, (5) assess heavy-duty vehicle emissions and fuel consumption reduction technologies, and estimate the environmental benefits and costs related to introducing these technologies into the U.S. vehicle fleet, (6) determine the volatility of UF PM emissions from CNG vehicles equipped with various types of emission control technologies.	See Below
Field Demonstration of 0.2 Grams Per Brake Horsepower-Hour NOx Natural Gas-Fired Engine	California Air Resources Board	The purpose of this research is to accelerate the commercialization of the Cummins Westport ISI natural gas engine that meets the 2010 NOx and PM standards. The engine will use spark ignition, exhaust gas recirculation technology with three-way catalyst technology, for improved efficiency and lower costs. With power ratings from 250 to 320 horsepower, the engine will meet the requirements of many bus and truck applications. A successful demonstration will promote the advancement of technology to control NOx emissions, reduce engine fuel consumption, and add another technology available to meet the 2010 standards	\$225,000

		for new engines and for retrofit applications.	
Using Gasoline, Diesel, and Compressed Natural Gas (CNG) Vehicles, Characterize the Significance of Lube Oil in PM Formation	California Air Resources Board	The purpose of this research is to: Determine, to what extent, lube oil affects PM emissions while under various operating conditions, including varied duty cycle and temperature changes. Determine what lubricant properties influence PM formation. Determine if a lubricant be formulated to reduce PM emissions. Understanding the formation characteristics of PM emissions from natural gas vehicles will help in the development of PM mitigation technologies. This in turn will reduce deployment barriers and help to expand the availability of vehicles capable of using alternative fuels.	\$100,000
Using the California Fleet, Conduct Physicochemical and Toxicological Assessment of Particulate Matter Emissions	California Air Resources Board	The purpose of this research is to determine the relative toxicity of volatile and non volatile PM fractions from heavy- and light-duty vehicles operating with, and without, control technologies. Testing will be conducted in ARBs vehicle emissions laboratories utilizing the unique USC particle concentrator technology for collection of sufficient emission samples for subsequent toxicological analysis. The USC particle concentrator is a PM collector that can capture coarse, fine and ultrafine fractions of PM. Testing and verifying potential impacts is necessary for expanding the availability, and promoting the use, of alternative fuel vehicles and engines.	\$225,000
Heavy-Duty Emissions and Fuel Consumption Improvement	California Air Resources Board	The purpose of this research is to evaluate the combination of vehicle platforms and technologies that would result in the greatest real-world emissions and fuel consumption improvements, particularly in the case of biofuel efficiency. This will be done by testing engines provided by OEMs that are currently in development and fueling them with ultra-low sulfur diesel, B20 and one or more other biodiesel blends. The testing will include a 13 mode transient cycle analysis, as well as cold and hot start testing.	\$150,000
Determining the Volatility of Ultrafine PM Emissions from Compressed Natural Gas Vehicles Control Technologies	California Air Resources Board	The objective of this research is to determine the volatility of UF PM emissions from CNG vehicles equipped with various types of emission control technologies representing near-term technology. In this project, researchers will collect samples of the UF PM for chemical speciation. This data will inform researchers as to the volatility of UF PM and will allow a better understanding of its formation, possible health effects, and control strategies. Once both the relative toxicity and volatility of UF PM emissions are known, emission control technology that will best protect human health can be identified for CNG vehicles. This, in turn, will reduce the deployment barriers and help expand the availability of vehicles capable of using alternative fuels.	\$350,000
Effect of Natural Gas Fuel Composition on Vehicle Performance and Emissions	UC Riverside	The purpose of this project is to evaluate the performance of natural gas vehicles using various natural gas blends (based on expected LNG imports to California) and the air pollutant emissions impacts of using those gases. The project will include developing the test protocols, identifying and obtaining vehicles/engines to test, selecting natural gas blends to test, obtaining and blending gases, testing and data analyses. Testing will address issues such as the impact of the different LNG blends on power, knock potential, fuel economy/CO2 and emissions of pollutants.	\$400,000
The Advanced Natural Gas Fuel Tank Project	University of Missouri, Columbia	The objective of this research is to cosponsor the development of natural gas vehicle tanks that are comprised of a less costly light weight material with strength and performance qualities similar to the carbon composites. Tanks have been modified to use carbon composites rather than the previous steel and aluminum. Using alternative tank materials and designs provide natural gas vehicles with an increase in storage capacity and driving range while reducing weight and cost barriers to ultimately produce a more competitive market for the natural gas vehicles as compared to their rival diesel and gasoline vehicles they are intended to replace. Specifically, the proposed project will refine adsorbed natural gas tank material made from corn cob and construct second generated Advanced Natural Gas (ANG) tanks.	\$1,000,000
Engine CHP Emission Control Technology	DE Solutions, Inc.	This project tests and adapts automotive emissions control components for use on stationary natural gas engines in CHP applications. The automotive systems use air/fuel ratio controllers, a robust 3-way catalyst, oxygen sensors, an oxidation catalyst, control software, diagnostics and alarms. CHP system manufacturer Tecogen Inc. will implement the new system on its engines so that the systems will exceed CARB 2007 emissions requirements and comply with SCAQMD rules regarding continuous compliance. Advances from the project are expected to begin being implemented in Tecogen products as early as 2009. The new system	\$749,013

Engine CHP Emission Control Technology	DE Solutions, Inc.	This project tests and adapts automotive emissions control components for use on stationary natural gas engines in CHP applications. The automotive systems use air/fuel ratio controllers, a robust 3-way catalyst, oxygen sensors, an oxidation catalyst, control software, diagnostics and alarms. CHP system manufacturer Tecogen Inc. will implement the new system on its engines so that the systems will exceed CARB 2007 emissions requirements and comply with SCAQMD rules regarding continuous compliance. Advances from the project are expected to begin being implemented in Tecogen products as early as 2009. The new system will be generally applicable to all rich burn engines.	\$749,013
Production and Conditioning of High Sulfur Biogas for Fuel Cell Combined Heat and Power Generation	Gas Technology Institute	In the context of a commercial application of food waste bio-power, the Gas Technology Institute will demonstrate high-sulfur biogas cleaning and conditioning to stringent fuel cell gas quality levels.	\$105,802
Integrated CHP Using Ultra-Low Nox Supplemental Firing	Gas Technology Institute	GTI will develop and demonstrate an ultra-low-NOx CHP system that packages a state-of-the-art 70 kW microturbine and a boiler with an innovative natural gas-fired supplemental burner. The burner is believed to have the capability of being scaled up to multi-megawatt gas turbine sizes, which would increase the CHP market potential.	\$987
Adaptation Strategies for Agricultural Sustainability in Yolo County, California	UC Davis	This project proposes to demonstrate the broad mechanisms by which agriculture may react to climate change, along with other simultaneous changes in landscape pressures, such as changes in profit potentials across commodities as well as population growth and urbanization. The case study will be for Yolo County, California, which represents a cross-section of a Central Valley agricultural landscape. The project will utilize climate modeling data from the 2008 Scenarios Project to describe spatial and temporal changes in temperature and precipitation across Yolo County. The main intent of the project is to provide a science-based exploration tool for scientists, farmers, policymakers and the general public to better understand the complexity of risks and responses to climate change, and to portray adaptation options for increasing agricultural sustainability (agricultural productivity and profitability, environmental quality, and social well-being).	\$290,000
Certification and Field Demonstration of a 0.2 g/bhp-hr NOx HPDI LNG Truck	Westport Power, Inc.	The objective of this research is to attain the 0.20 g/bhp-hr NOx level while equaling or exceeding equivalent diesel engine performance and fuel efficiency before diesel engines attain this 2010 emission level requirement. Researchers will develop advanced versions of the existing Westport ISX-G HPDI LNG heavy-duty engine, based on the Cummins 15 liter ISX diesel engine. LNG is the fuel chosen for this project due to the ability to carry enough fuel on board for extended operation and due to the high-pressure fuel injection characteristics of the technology.	\$500,000
San Jose State University Foundation Environmental Business Cluster (EBC)	San Jose State University Foundation	Provide PIER funded contractors commercialize their technologies through market assessment, business plan development and links to financial community.	\$45,418
Expansion of proprietary models to conduct research on California natural gas infrastructure and California natural gas market demand scenarios	Black & Veatch Corporation / Lukens Energy Group	This project involves analyzing the California and Western North America natural gas markets to understand whether natural gas underground storage will play a significant role in meeting natural gas demand needs for the forecasted growth in the California natural gas market. The analysis will consider competing assets to underground natural gas storage, review out-of-state alternatives and review potential impediments to the increase of natural gas underground storage in California. The final deliverable will be a report that develops conclusions with specific discussion on the analysis and the means to arrive at these conclusions.	\$266,277
Developing a multi-state natural gas infrastructure simulation model to analyze the value of natural gas storage in	Energy & Environmental Analysis, Inc.	The proposed research will consist of two major components: (1) Two conceptual papers that describe the role of natural gas storage in the California and broader North American energy markets and juxtapose how gas storage is valued by individual market participants versus how it might be valued from the perspective of public benefits and public policies and (2) 30 analytic case study reports based on a fully specified computer	\$732,733

Developing a California natural gas storage technology research assessment	Gas Technology Institute	The Gas Technology Institute, with input from Southern California Gas Company, Pacific Gas and Electric and the two independent California storage operators, will research issues surrounding Californias utilization of underground natural gas storage. The storage operators will assist by supplying historic and current consumer usage data to forecast California demand, natural gas storage operational experience, and expertise interpreting data and formulating California market demand patterns. The project's major tasks are: Defining California Market Demand Fluctuations and Trending. Defining California Natural Gas Storage Deliverability Options when incorporating LNG assets into Californias gas storage infrastructure, and the potential development and coordination with existing underground storage sites. Reviewing Regulations and Policy and analyzing existing regulatory policy, including market power threshold tests as it pertains to gas storage enhancement and expansion.	\$350,082
Barriers to Expansion of Natural Gas Storage Facilities in California	MRW & Associates	This project specifically addresses barriers to increased natural gas storage in California with an emphasis on the market power threshold test by conducting a comprehensive analysis of barriers to expanded independent gas storage infrastructure in California. This analysis will draw upon existing academic literature on market power and market power threshold tests in the energy industry. The overall purpose of this research is to provide an assessment of whether market power threshold tests or other entry barriers are inhibiting independent gas storage infrastructure development in California and to evaluate possible changes to these tests that would allow for increased infrastructure development.	\$109,077
Developing a Low Cost, Daily Simulation Model of the California Natural Gas Transportation and Storage Network	UC Davis	The purpose of this research is to develop an analytical tool that will help inform policy, infrastructure and daily operational decisions in the California natural gas network. The tool is a model of the pipeline and storage natural gas network in California, detailed enough to represent daily transportation and storage operations. Engineering, economic and institutional information will be combined so that the model solves for a flow and inventory profile under a set of conditions that are as close as possible to the ones faced by actual participants in the natural gas market. The model will solve for the most efficient natural gas allocation for California while testing for the introduction of LNG, infrastructure expansions, modifications to regulatory constraints, and changes in seasonal demand.	\$55,948
		Total	\$11,273,239

Table 14: PIER NG Research Projects Funded in FY 2007

Title	Company	Research Description	Funding
Improved Natural-Gas Fired Aluminum Smelter Burner	Gas Technology Institute	GTI proposes to install a demonstration of a commercial size prototype flex-flame burner in California. Thorock Metals in Compton, California hosted the early demonstration tests. Field demonstration is slated to be conducted over two years and will consist of parametric and life-cycle tests to optimize operating conditions, to confirm burner reliability, and to collect data on decreased emissions and energy use. The burner design is expected to lend itself to mass production.	\$10,000
Hot Water Distribution System Research	Heschong Mahone Group	This will be an integrated program of research that analyzes how HWDS function in the field, and what factors lead to successful outcomes. It will identify what aspects of system design, operation and maintenance offer the greatest opportunities for energy savings from utility programs and changes to water and energy efficiency standards, and which of these opportunities can most readily be achieved given cost constraints, typical design practice, available technologies and cultural factors. Many energy saving opportunities will be identified and quantified, and market change will be achieved by: Providing evidence of achievable savings to building owners and designers. Providing design advice to make the design process easier and cheaper. Working with product manufacturers to improve performance and/or reliability. Informing the development of codes and standards, and of utility programs.	\$929,841
Water Heating and Hot Water Usage in California Homes	Lawrence Berkeley National Laboratory	The proposed research will continue efforts to characterize residential hot water usage through a partnership with the Department of Water Resources (DWR). This project will measure how much water and energy is wasted in hot water distribution systems (HWDS) in California residences and investigate the effectiveness of current retrofit options in reducing this waste of water and energy. This research will also continue supporting the market introduction of efficient gas storage water heaters by providing evaluations of promising technology innovations. This project will conduct efficiency tests on three promising, alternative storage-type gas water heaters. The proposed research also includes the continuation of efforts to collect the necessary data, conduct analysis and develop recommendations for energy-related code changes to improve the efficiency of HWDS.	\$570,500
California AUAV Air Pollution Profiling Study	Scripps Institution of Oceanography - UC San Diego	The research team will use light-weight Autonomous Unmanned Aerial Vehicles (AUAVs) to routinely profile the atmospheric concentration of black carbon, aerosol, carbon monoxide, and ozone, and solar radiation over a period of one year. Data from the vertical profiles of pollution up to 12,000 feet above sea level combined with wind back trajectories will help to sort out the original sources of pollution and, in particular, of black carbon. The researchers will use the collected data to estimate the climatic effect of BC in California.	\$698,991
Atmospheric Measurements and Modeling for Verification of AB-32 Mandated GHG Emissions Reductions	Lawrence Berkeley National Laboratory	The objectives of this project are to: Evaluate inter-annual variations in GHG concentrations and resulting surface emissions; Analyze and refine meteorological model output to quantify and reduce the uncertainty in GHG emission estimates caused by errors in modeled atmospheric transport; Initiate continuous N2O measurements at the Walnut Grove tower site to produce the first atmospheric "top-down" estimates of N2O emissions for California's central valley; Collect stable carbon isotope measurements of CO2 and CH4 (13CO2, and 13CH4) at the WGC tower and evaluate the use of the isotopic measurements for attributing emissions to different source types at the regional scale.	\$505,000
Energy and Water Recovery with Transport Membrane Condenser	Gas Technology Institute	The Gas Technology Institute (GTI) has developed a Transport Membrane Condenser (TMC) as part of a heat recovery system for gas fired boilers. The TMC is designed to recover water vapor and its latent heat, which normally accounts for about 68% of the total heat lost up the stack. The TMC accomplishes this by condensing water vapor inside the ceramic membrane pore structure, so the gas side heat transfer resistance is greatly decreased and the overall heat transfer coefficient increased. GTI seeks to apply the TMC to applications in food processing, paper drying, and chemical industries. Based on data collected to date, these processes produce low-grade heat with even higher moisture contents (i.e., 20% and up), which is even more favorable for the TMC performance.	\$479,650

Advanced Residential Energy and Behavior Analysis Project	Portland State University	The project will apply advanced analytic techniques to the best data on residential energy use and efficiency choice, to improve our understanding of the changing landscape of residential consumption and develop next-generation models to support effective carbon-reduction policies and programs.	\$668,857
Energy Efficiency Calculator Tools	Southern California Gas Company	To develop Web-based software and desktop tools to aid California industries to identify, analyze, and prioritize energy (i.e. natural gas and other alternate energy sources) savings opportunities. The tools are designed to help industrial endusers in analysis of energy saving opportunities and savings (energy in terms of MM Btu/year, energy cost in terms of US\$ and CO2 savings) by implementing selected energy saving projects.	\$200,000
Gaseous Fuel Interchangeability Criteria Development	UC Irvine	The goal of this project is to develop gas fuel interchangeability criteria that will help combustion system operators, manufacturers and regulatory agencies to predict fuel variation impacts before provisioning for these different fuels. The program will focus on combustion system efficiency, durability, and emissions and how they are affected by fuels that may not meet present day fuel specifications. The program will focus specifically on flame speed, autoignition, flashback, lean blowout, emissions and the chemical kinetics of different fuels. Quantification of these fundamental combustion properties will be accomplished for a well-defined matrix of fuel compositions that will span those foreseen potential alternate fuels for conditions of interest to various applications. The data collected will be compiled into a unified combustion database that will be used to develop the gas fuel interchangeability criteria. This project will be coordinated with and expand on the existing Public Interest Energy Research looking at natural gas interchangeability for industrial and commercial burners, appliances and vehicles.	\$1,132,714
Waste Heat Recovery from Corrosive Industrial Exhaust Gases	Gas Technology Institute	Aluminum remelters typically operate at 30% efficiency with 60% of input energy lost to the exhaust gas without recovery. More than 5 million tons of aluminum are remelted annually in the U.S., and more than 10% of that total is remelted in California. A total of 20 trillion Btu of natural gas is used to remelt aluminum annually. A recuperation technology to recover 43% of the exhaust gas heat would increase process overall efficiency to 40% and save 5.2 trillion Btu of natural gas annually in the U.S. and more than 0.52 trillion Btu per year in California aluminum remelt furnaces. The savings of 26% of fuel gas results in the same 26% decrease in CO, CO2, and NOx emissions. The GTI Gas Guard Recuperator (GGR) technology takes a practical, innovative approach to heat recovery. Hot exhaust gas passes through a guard bed of sacrificial sodium minerals that scour chlorine and fluorine from the gas. Hot, clean gas then passes through a conventional heat exchanger that preheats air for heat transfer to the burners.	\$448,852
Ultra Low Nox Burners	Gas Technology Institute	The purpose of this project is to develop and demonstrate a 5-ppmv ultra-low-NOx burner for industrial water tube boilers that is based on GTI's patented Forced Internal Recirculation technology. GTI has teamed up with Coen Company of Burlingame to develop this burner and demonstrate it at a site in Pasadena (California Institute of Technology). The FIR burner is capable of reaching this level of NOx emissions with reduced flue gas recirculation and lower excess air than other types of ultra-low-NOx burners. In this project, the burner has been developed and a 62-million-Btu/h prototype will be demonstrated on a water tube boiler at the Pasadena site.	\$75,762
A 100 kW dual shell Stirling engine integrated with a catalyzed flow burner designed to meet the CARB 2007 emission standards	ADI Thermal Power Corporation	ADI Thermal Power will group four of its 25 kW Stirling engines into a 100 kW, four-cylinder engine package, integrate a new steam reformer module to convert some of the otherwise wasted exhaust thermal energy to chemical energy of a fuel, modify the burner system to meet California Air Resources Board (CARB) 2007 emission requirements, and add an overall control system to maintain emissions performance and meet facility electrical and thermal needs.	\$249,536
Removal of Siloxane and H2S from Biogas using Microwave Technology	Sacramento Municipal Utility District	This project will demonstrate a biogas treatment system combining media adsorption and microwave treatment that can do the following: Demonstrate that use of molecular sieve media and carbon adsorbent to remove H2S, siloxanes, and other contaminants from biogas, combined with the microwave-induced regeneration of media and destruction of these contaminants is effective, economical and can be implemented at landfills and digesters in California.	\$267,381

Biogas-Powered 100kW Microturbine with Ultra-low Emissions for CHP Applications	Lawrence Berkeley National Laboratory	Lawrence Berkeley National Laboratory will demonstrate a recuperated microturbine with a low swirl ultra-low emission combustor designed for operation on biogas and capable of meeting the California Air Resources Board (CARB) 2007 distributed generation emission standards for fossil fuels (which is same as CARB proposed 2013 Waste Gas Emission Standards). The proposed unit will operate as a combined heat and power (CHP) system. It will replace natural gas by using digester gas produced at a waste water treatment facility. The waste heat from the microturbine will be used at the facility.	\$142,935
Reducing California Industrial Natural Gas Consumption Through Advanced Biomass Gasification	Diversified Energy Corporation	Diversified Energy Corporation (DEC), Gilbert, AZ and the Energy and Environmental Research Center (EERC), University of North Dakota, Grand Forks, ND have teamed with Evergreen Pulp, Inc. (EPI), a pulp and paper mill located in Eureka, CA, to propose an integrated biomass gasification demonstration project utilizing HydroMax, an advanced gasification process, to convert waste wood fines at EPI into usable syngas for process heating.	\$500,000
Integrated CHP Using Ultra-Low_Nox Supplemental Firing	Gas Technology Institute	GTI will develop and demonstrate an ultra-low-NOx CHP system that packages a state-of-the-art gas turbine and boiler with an innovative natural gas-fired supplemental burner. GTI will conduct a field trial and demonstration of the ultra low- NOx burner technology with a 70 kW microturbine. The burner is believed to have the capability of being scaled up to be used with a multi-megawatt gas turbine, which would increase the CHP market potential.	\$500,450
Natural Gas Vehicle Research: Industry Applications	National Renewable Energy Laboratory	In coordination with the ARB, the PIER Transportation Subject Area produced a research roadmap for natural gas vehicles (CEC-500-2008-044-D). The natural gas vehicle research roadmap (NGVRR) identified funding initiatives essential to resolving barriers affecting deployment of natural gas vehicles in California. The NGVRR recommends participation in NREL's Natural Gas Vehicle Technology Forum in order to effectively implement research results and assure that research efforts are connected to NGV markets. This research partnership with NREL, a preeminent alternative fuels research organization, will help maximize the implementation of the NGVRR. Resources, data, and input from key stakeholders critical to successful implementation of the NGVRR need to be developed and deployed to effectively target research support to provide the greatest acceleration of NGV penetration toward full market potential.	\$100,000
California Transportation Fuels Crops Development and Demonstration Program	California Department of Food and Agriculture	CDFA will conduct a three-year research project to determine California's potential options for cultivating energy crops suitable for biofuels production. CDFA will provide at least \$500,000 of in-kind contributions of management, labor, technical expertise, land, water and other resources. A technical advisory committee (TAC) will be established to guide the program and ensure the research is informed by the latest national and international research relative to purpose grown crops.. This committee will be closely coordinated with the California Biomass Collaborative at University of California, Davis.	\$1,000,000
Purification and Liquefaction of Biomethane Landfill Gas for Transportation Fuel	Gas Technology Institute	GTI will develop and demonstrate a system to convert landfill gas into liquefied natural gas (LNG) to be used as motor fuel for heavy duty vehicles. Gas clean-up research is to be led by Linde-BOC, the largest supplier of cryogenic gas products in the world. Commercialization and deployment efforts will be performed through Waste Management Incorporated (WMI), the largest landfill owner/operator and a large consumer of LNG in refuse trucks in the US. The project will be sited at WMI's Altamont Landfill in Livermore, and LNG generated will fuel WMI's fleet of heavy-duty vehicles.	\$998,000
Solar Thermal Heat Pump/Chiller	Energy Concepts Company	The purpose of this project is to demonstrate the feasibility of converting solar thermal heat to a combination of chilling plus heat pumped hot water with a solar thermal powered absorption heat pump (Helisorber).	\$95,000
Testbed Design for Gas Turbine Exhaust Pressure Recovery	Meruit, Inc.	The purpose of this project is to determine the feasibility of constructing a full-scale testbed that would experimentally validate Annular Recirculating Diffusers (ARDf) that would recover gas turbine exhaust kinetic energy and provide the calculated nominal three % thermodynamic improvement in turbine performance.	\$49,750
High Efficiency Heat and Power System for CCHP Applications	Altex Technologies Corporation	The goal of this project is to show, through testing, the ability of the High Efficiency Heat and Power System (HEHPS) combustor to meet ultralow emissions goals of 2ppm NOx and 6ppm CO over a five-to-one turndown. In addition, validated analyses will show the ability of HEHPS to produce electric power at 45 %	\$94,915

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Feasibility Assessment of Operating Gas Engines on Alternative Gas Fuels	Colorado State University	The goal of this project is to determine the feasibility of operating existing natural gas engines on alternative gas fuels through methane number measurements.	\$95,000
A Pore Flow Reactor for Landfill Gas Clean-up	University of Southern California	The goal of this project is to demonstrate the use of the Pore Flow Reactor concept in conjunction with nanocatalysis, in order to maximize the efficiency of NMOC destruction technology.	\$95,000
Enabling the thermochemical production of hydrogen from water: investigation of the Bunsen reaction in a low vapor pressure solvent	Oregon State University	The purpose of this project is to determine the feasibility of performing the Bunsen reaction in a low vapor pressure solvent to enable the practical implementation of the thermochemical production of hydrogen from water.	\$95,000
Highly Efficient Production of Electricity and Syngas Using a Natural Gas Fuel Cell	Functional Coating Technology, LLC	The purpose of this project is to determine the feasibility of syngas and electricity production from natural gas using Segmented-in-series solid oxide fuel cell (SIS-SOFC) modules and stack.	\$94,998